DEVELOPMENT AND DESIGN
OF
MILL CONSTRUCTED BUILDINGS

BY

P. M. LEICHENKO
M. L. LOEWENBERG

ARMOUR INSTITUTE OF TECHNOLOGY

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 of mill constructed

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THE DEVELOPMENT AND DESIGN OF MILL CONSTRUCTED BUILDINGS

A THESIS

PRESENTED BY

PETER M. LEICHENKO AND MAX L. LOEWENBERG

TO THE

PRESIDENT AND FACULTY

OF

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Dean of Cultural Studies

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OUTLINE AND INDEX

PART ONE.

SUBJECT. PAGE.

INTRODUCTION 1 - 10
  History 1
  Definition 3
  Development 8

UTILITY 11 - 13
  Factories 12
  Warehouses 12
  Shop Buildings 12
  Other Uses 13

MATERIALS USED 14 - 44
  Timber 14
    " Definitions 19
    " Photographs 21
    " Specifications General 31
    " Grades 33
  Steel 36
  Cast Iron 40
  Brick 40
  Concrete 43

37186

SUBJECT. PAGE.

METHODS OF CONSTRUCTION 45 - 65
  Walls and Foundations 45
  Floors 53
  Columns 55
  Girders 59
  Joists 61
  Rough Floors 61
  Laminations 62
  Finished Floors 63
  Roof 64

DETAILS OF DESIGN 66 - 68
  Occupancy 66
  Size 66
  Location 67
  Loading 67
  Spans 67
  Special Requirements 68

DETAILS OF CONSTRUCTION 69 - 74
  Timber Decay 69
  " " Prevention 72
  Ventilation 73
  Painting 74

SUBJECT. PAGE.

FIRE PROTECTION 75 - 81

General Requirements 75

Sprinkler System 79

COST 82 - 96

Materials 82

Labor 83

Erection 84

Maintenance 85

Obsolescence 86

Cost Data 88

Comparatice Cost Tables 92

SUMMARY 97 - 103

CONTENTS OF STORAGE WAREHOUSES 104 - 105

PART TWO.

OUTLINE OF DESIGN 106 - 108

DESIGN OF ROOF 110 - 112

" " FLOORS 113 - 116

" " GIRDER OVER DRIVEWAY 117

" " COLUMNS 118

" " PIERS 119-- 122

" " WINDOWS 123

" " STAIRS 123

" " TANK TOWER FRAMING 125 - 128

" " TYPICAL COLUMN FOUNDATIONS 128 - 131

SUBJECT.		PAGE.
DESIGN OF TYPICAL PIER FOUNDATIONS		132 - 134
" " DRIVEWAY COLUMN FOUNDATIONS		135 - 136
" " WALL FOOTINGS		137 - 144
" " CHIMNEY STACK		145 - 147
" " LINTELS		148 - 150
FORMULAE USED		151
GENERAL FORMULAE FOR FLEXURE OF BEAMS		152 - 158
SPECIFICATIONS		159 - 199
General Conditions	160	
Masonry	164	
Concrete	170	
Carpentry	175	
Structural Steel	184	
Fireproof Doors	188	
Fireproof Windows	192	
Composition Roofing	194	
Automatic Sprinkler System	196	
DRAWINGS.		200 - 205
Elevation and Section	200	
Foundation Plan	201	
Basement Plan	202	
First Floor Plan	203	
Typical Floor Plan	204	
Roof Plan and Details	205	

PART
ONE.

INTRODUCTION.

Building construction has kept pace with the progress and development of modern arts and sciences, and has adapted itself to the needs of times and conditions. The building art in itself is of ancient origin, starting in times immemorial and developing gradually with the progress and civilization of the human race.

Buildings were erected to meet the requirements of the community or the individual, and were classified according to their style of architecture. The available building materials were limited in number and therefore no attempt was made to classify buildings with respect to their structural features. The actual classification of various types of building construction is of comparatively recent origin.

In the design of a building, usage, economy, location, strength, durability, sanitation and fire protection must be kept in mind. Definite types of buildings were developed for the different types or kinds of industries, with particular attention to economy of operation. Each location has developed its own type of buildings, based on the materials available in the immediate vicinity.

The specialization of industry brought with it definite requirements as to strength and durability of the materials entering into the construction of industrial buildings. It also brought with it definite requirements with regard to the sanitation of the buildings in its relation to the various materials used: it being now universally recognized that proper sanitation will decrease the cost of upkeep of the building and increase its life. It also decreases the cost of production, as clean and light surroundings increase the productivity and efficiency of the operatives.

The question of fire protection has its separate place in the development of industrial buildings, being a great economic factor in lowering insurance rates and lessening the period of enforced idleness due to possible destruction of the plant by fire.

The modern building designer has at his disposal many kinds of raw material. At his disposal are brick, stone, tile, steel, concrete, wood, etc. The number of these materials are so large and varied that at times it is difficult for the designer to choose from them the proper kinds for a definite type of building.

The various types developed can be roughly divided into the following classes:

1. Fireproof Construction.
2. Mill Construction.
3. Slow Burning Construction.
4. Ordinary Construction.

The Chicago Building Ordinance gives the following definitions for these classes:

FIREPROOF CONSTRUCTION.

The term "fireproof construction" shall apply to all buildings in which all parts that carry weights or resist strains, and also all exterior walls and all interior walls and all interior partitions and all stairways and all elevator enclosures, are made entirely of incombustible material, and in which all metallic structural members are protected against the effects of fire by coverings of a material which shall be entirely incombustible, and a slow heat conductor, and hereinafter termed "fireproof material."

FIREPROOF MATERIAL - The materials which shall be considered as filling the conditions of fireproof covering are: First, burned brick; second, tiles of burnt clay; third, approved cement concrete; fourth, terra cotta.

SLOW BURNING CONSTRUCTION.

The term "Slow-Burning Construction" shall apply to all buildings in which the structural members, other than walls elsewhere required to be of masonry, which carry the loads and strains which come upon the floor and roofs thereof are made wholly or in part of combustible material, but throughout which the structural metallic members, if used, shall be protected against injury from fire by coverings of fireproof material. The lower five feet of metal columns shall be protected as required in Section 34 of this Chapter. Underside of joists shall be protected by a covering of three coats of plaster laid on metal lath; and a layer of mortar or other incombustible material at least one and one-half inches thick shall be applied on all floors and roof surfaces above the joists of the same.

POSTS, GIRDERS AND PARTITIONS - Wood posts, if used, shall be of not less than one hundred square inches sectional area. Wood girders, if used, shall be of not less than seventy-two square inches sectional area. All partitions in buildings of this type shall be made entirely of incombustible material. Wood furring, wood studs and wood lath shall not be permitted in buildings of this type.

STAIRS, CONSTRUCTION OF - Where buildings are required to be of "slow-burning construction, all stairs in such building shall be of incombustible material, except as hereinafter provided. Said stairs may be of ordinary construction, if said building is equipped with an automatic sprinkler system, and stairs are enclosed in a fireproof wall.

ORDINARY CONSTRUCTION.

The term "Ordinary Construction" means the ordinary system of construction in which timber and iron structural parts are not protected with fire-resisting coverings and in which the walls are of masonry.

It is our purpose in this paper to discuss the type of building commonly known as "Mill Constructed".

The term "Mill Construction" in general applies to the type of building where the interior framing and floors are of heavy timbers, avoiding a multiplicity of corners and concealed spaces which may not be readily reached in case of fire. This brings with it one of the chief advantages of a "mill constructed" building, namely that of retarding as far as possible the progress of a fire from one part of the structure to the other.

This is accomplished by using heavy solid masses of timber for the structural members, separating different stories by heavy timber flooring, enclosing all shafts and floor openings with incombustible walls, and protecting all wall openings with fire doors or wire glazed metal windows.

Of the various definitions given for the term "Mill Construction", the one given by the Chicago Building Ordinance is the most comprehensive. To quote the ordinance:

> MILL CONSTRUCTION REQUIREMENTS - The term "Mill Construction" shall apply to all buildings in which wooden posts, if used, have a sectional area of not less than one-hundred square inches, and wooden girders and joists a sectional area of not less than seventy-two square inches, and roofs, if of wood, a thickness of not less than two and five-eighths inches in a single layer, and floors, if of wood, a thickness of not less than three and one-half inches in not more than two layers, the lower one of which shall be not less than two and five-eighths inches in thickness, and in which all structural metallic members, if used, are fireproofed as required for fireproof construction. When metallic lintels are used to cover wall openings, the fireproofing on the underside may be omitted where such lintels are fireproofed on the other three sides and all voids in them are filled solid with fireproof material. All floors and roofs not constructed as above shall be of fireproof construction as elsewhere required for fireproof construction in this ordinance.
>
> FIREPROOFING - (a). Partitions in buildings of mill construction shall be made entirely of incombustible material. If iron columns, girders or beams are used in buildings of this type, they shall be protected as specified in this chapter; but the wooden posts, girders and joists need not be protected by fireproof covering. Wood furring, wood studs and wood lath shall not be permitted in buildings of this type.

FIREPROOFING - (b). If reinforced cinder concrete construction is used in the structural parts of a building which is required to be of slow-burning or mill construction by this chapter, then all partitions shall be of incombustible material and all parts other than structural parts and partitions of the building shall be as required for slow-burning or mill construction buildings by this chapter.

STAIR CONSTRUCTION WHERE AUTOMATIC SPRINKLER SYSTEM IS INSTALLED - In buildings required to be of "mill construction," all stairs in such buildings shall be of "incombustible"material, except as hereinafter provided.
Said stairs may be of wood construction if said building is equipped with an automatic sprinkler system and stairs are enclosed in a fireproof wall.

To further illustrate what is meant by "Mill Construction", and to clear up all misconceptions regarding the same, the following extract from Report No. 5 of the Insurance Engineering Experiment Station of the Boston Manufacturers' Mutual Fire Insurance Company will be given:

> "Mill-construction does not consist in disposing of a given quantity of materials so that the whole interior of a building becomes a series of wooden cells; being pervaded with concealed spaces, either directly connected each with the other or by cracks through which fire may freely pass where it cannot be reached by water.
>
> It does not consist in an open-timber construction of floors and roof resembling mill-construction, but of light and insufficient size in timber, and thin planks, without fire-stops or fire-guards from floor to floor.
>
> It does not consist in connecting floor with floor by combustible wooden stairways encased in wood less than two inches thick.

It does not consist in putting in very numerous divisions or partitions of light wood.

It does not consist in permitting the use of varnish upon woodwork over which a fire will pass rapidly.

It does not consist in leaving windows exposed to adjacent buildings unguarded by fire-shutters or wired glass.

It is dangerous to paint, varnish, fill or encase heavy timbers and thick plank as they are customarily delivered, lest what is called dry-rot should be caused for lack of ventilation or opportunity to season.

It does not consist in leaving even the best-constructed building in which dangerous occupations are followed without automatic sprinklers, and without a complete and adequate equipment of pumps, pipes, and hydrants.

It follows that if plastering is to be put upon a ceiling following the line of the underside of the floor and the timber, it should be plain lime-mortar plastering which is sufficiently porous to permit seasoning. The addition of the skim-coat of lime-putty is hazardous, especially if the top floor is laid upon resin-sized or asphalt paper. This rule applies to almost all timber as now delivered.

All the faults above recited have been committed in buildings purporting to be of mill construction, and all form a part of the common practice in 'combustible architecture'."

A very general and most universally accepted definition of Mill Construction applies to buildings where all floor and roof joists and girders have a sectional area of at least 72 square inches, timber flooring not less than 3-1/2 inches in thickness, wooden posts at least 100 square inches in area, and roof boards not less than 3 inches thick.

The mill constructed type of buildings originated with the cotton mills of England, in the early stages of that industry. Its development is marked by well defined steps which can be ascribed to certain definite factors.

In the early period of factory development, mills were located near the only source of power then available, namely - a running stream of water. Although the rivers usually had a constant and considerable flow, yet the power available after being transmitted by the primitive water wheel was very limited. Due to this lack of sufficient power, care had to be taken to have all the machinery located as near the source as possible, in order to reduce friction and transmission losses. As a result, the mills were narrow, low and of light construction.

The discovery of steam as a motive power revolutionized the cotton industry and brought with it nrw methods of manufacture, new and heavier machinery, and, what is most important, made possible the location of mills at any convenient place. This meant larger and heavier buildings to house this machinery, and more solid buildings to take the vibration caused by the new and as yet crude power machines. This laid the foundation for the modern mill constructed building.

Nasmith, in his book "Recent Cotton Mill Construction says:

> "Generally speaking, the English mills of 1825-1865 era were constructed with wooden floors, supported on transverse wooden beams, crossed by longitudinal joists, and the whole floor was thus a hollow timber construction of an exceedingly inflammable character."

The year 1870 saw the establishment of joint stock companies, which greatly increased and extended the cotton industry. This led to the use of large machines and larger buildings to house them, with the consequent increase of window space and higher ceilings. The design of industrial buildings from this period up to the present day has been governed by the following conditions:

(1) The increased competition due to economic causes.

(2) The improvement of machinery.

(3) The choice of building materials.

As competition began to play an important part in the development of the cotton industry, ways and means had to be devised to utilize the full working power of the operatives. This could only be accomplished by the use of larger and better machinery, as a help to labor.

The inventive genius of the machinist keeping up with the requirements of the times produced the necessary machinery, of larger size and capacity.

In order to accomodate these larger machines, suitable buildings had to be erected, yet keeping the cost of such of such buildings as low as possible, to reduce the overhead charge on the output.

This was brought about by the introduction of new building materials and improved facilities for obtaining and transporting the other building materials.

The availability of building materials has a great effect on the resulting type of buildings. This can be best illustrated by the difference between the cotton mills of our country and those of the English proto-type.

The abundance of good structural timber in this country enabled the mill owner to utilize it to advantage for construction purposes, gradually developing the modern American type of mill constructed building. On the other hand, the English mill builders, having but a limited supply of building timber, and a large supply of iron, developed their present fireproof type of mill buildings.

UTILITY.

The modern mill constructed type of building is used for a great many purposes other than cotton mills. It is used for factories, warehouses, shop buildings, etc.

There are many reasons for using this type of building for commercial purposes, namely:

(a) Ability to fasten and suspend machinery and shafting and rearranging same with the least trouble and expense.

(b) Reduced chance of delay of operation due to machinery and shafting getting out of alignment, accomplished by the rigidity of this type of construction.

(c) Its ability to support heavy superimposed loads on all floors.

(d) The use of heavy timbers permit large spans allowing the placing and storage of bulky merchandise and machinery. Large spans also enable factory operations not otherwise possible, and cheapen the cost of handling merchandise.

(e) Certain classes of merchandise are very susceptable to dampness and cannot be stored in any but absolutely dry buildings. Mill constructed buildings answer these specifications to a high degree.

(f) Mill constructed buildings employing heavy timber framing and steel lintels make possible the use of very large windows extending from pier to pier and to ceiling, thus admitting a maximum amount of light.

(g) The capacity of this type of building to adapt itself to changed conditions and requirements of occupancy by being easily rebuilt or remodelled.

From the above, it can readily be seen that a type of building having these characteristics is well suited for factory and shop purposes, as it makes possible the moving and rearranging of machinery or equipment from one place to another, without much trouble or expense.

Steel or iron post caps, heavy timbers, solid floors, all tend to make towards rigid construction, thus reducing wear and tear on machinery due to vibration of the building.

A light and sanitary building increases the productivity of the employes and makes for a better and more contented worker.

The chief requisite for a warehouse is its ability to carry heavy and bulky loads in clean and damp-proof surroundings.

This is best accomplished in a mill constructed building, with its heavy timber framing, designed to carry any desired load, and with spans of sufficient length to economically store merchandise.

Mill constructed buildings are well adapted for other purposes, such as stores, office buildings, school houses, mine buildings, stables, etc.

MATERIALS USED.

TIMBER.

Among the structural materials used in a mill constructed building are wood, steel, cast iron, brick, concrete, etc., all of which have certain specific attributes to recommend them to the designer.

It is frequently a problem to determine which material to use for any one part, and only the skill and experience of the designer will decide what material shall be used. The choice of materials will depend upon the availibility of the material in the locality where the building is being erected, ease of transportation and the prevailing market prices.

One of the most important materials used in a mill constructed building is wood. America is distinctly a wood using nation. Our annual consumption of timber is between forty and fifty billion feet, which means about three hundred cubic feet per capita per year. In this connection it is interesting to note that England uses only fifteen cubic feet per capita per year.

There are many kinds of wood used for construction purposes, such as Yellow Pine, Douglas Fir, White Pine, Hemlock, Cypress, etc. The suitability of timber for construction purposes depends most of all upon the internal structure of the wood, i. e., texture and grain.

The properties of wood are, strength, elasticity, density, toughness, hardness, cleavability, shrinkage, etc.

The most widely used structural timber in this part of the country is yellow pine. The average annual cut of coniferous wood in the United States is thirty four billion feet, board measure, which is 76 per cent. of the total cut, including the hardwoods. Of the coniferous woods cut, the Southern Yellow Pines amount to 37 per cent., or about four times as much as the most plentiful competing wood.

The commonly known varieties of Yellow Pine are:

(1) Long Leaf.
(2) Short Leaf.
(3) Loblolly.

The predominating species of these woods are the long leaf pines. In 1913 there were 232 billion feet of long leaf, and 152 billion feet of shortleaf and loblolly, making a total of 634 billion feet of standing timber in the Southern pine region; cypress 40.4 billion feet; and all hardwoods together 209 billion feet.

The division of Yellow Pines into Long Leaf, Short Leaf, Loblolly, etc., was originally based on the botanical characteristics of the timbers. They are described as follows:

Long leaf yellow pine is resinous, fine grained, and averages about 43.7 pounds per cubic foot of heart wood.

Short leaf yellow pine is medium, coarse grained, has a very small percentage of resin, and averages about 38 pounds per cubic foot of heart wood.

Loblolly pine is coarse grained, light weight, averaging about 34 pounds per cubic foot, is not very resinous, and has a small percentage of heart wood.

As the timber industry grew in volume, the terms "long leaf" and "short leaf" began to be used as terms descriptive of quality rather than of botanical species. Thus, "long leaf pine" was used for all timbers, such as botanical short leaf, Cuban, or long leaf, grown under such conditions that it produces a large percentage of hard summer wood, so as to be equivalent to the word produced by true botanical "long leaf".

"Short leaf pine", in turn, would cover all varieties of pine grown under conditions producing a wood equivalent to botanical short leaf pine.

The most desirable species of yellow pine for structural purposes is true long leaf pine, but of recent years the average engineer, architect or other buyers of large quantities of Southern yellow pine found their shipments, bought under specifications calling for long leaf pine, to be a mixture of long leaf, short leaf, loblolly, etc. It is very difficult to tell the difference between the species, and endless disputes would arise between the seller and the buyer.

The writers time and again had occasion to reject large shipments of lumber, because of its inferior quality. Yet, this timber was bought under "long leaf" requirements, and the services of experts were frequently required to determine the true species of the wood. In our case, it was necessary to send samples of timber delivered to the job, to the United States Forest Products Laboratory at Madison, Wisconsin, to determine by microscopical analysis the true species of the wood.

This clearly illustrates the difficulty of obtaining proper structural yellow pine, even by the experienced buyer or engineer. The inexperienced user was supplied with inferior timber, with the consequent early and extensive deterioration of the building.

It was finally recognized by the manufacturers and consumers of Southern yellow pine, that a more simple method for classifying various kinds of Southern yellow pine for structural purposes was necessary, which would tend to end all disputes as to the different grade of timbers. Realizing this condition, the United States Forest Service, the American Society for Testing Materials and the various Southern Yellow Pine Associations actively cooperated for the purpose of finding some method for distinguishing the various classes of pine for structural purposes.

The American Society for Testing Materials made some suggestions along these lines in 1909, proposing the grading of timber based on the number of annual growth rings per inch. Investigations carried on by the United States Forest Service during the succeeding five years indicated that this basis for classification was not clear enough and could not be depended upon as a basis for structural requirements.

In 1914 the Forest Service conducted a very extensive series of investigations to determine the relationship between the number of rings per inch, the percentage of summer wood, the degree of contrast between the summer and spring wood and its strength. The result of these investigations was the recommendation by the Forest Service of a series of rules to be used as a standard in classifying timber. In drawing up such rules to cover a higher grade of structural timber than was generally supplied to the market, the first condition must be that such rules will exclude practically all material that should not be used in building construction, with the fiber stress recommended for the grade. The next condition must be that such rules will not exclude more than a reasonable amount of material properly belonging to the grade from the standpoint of strength.

The new rules as adopted by the American Society for Testing Materials are as follows:

DEFINITION FOR SOUTHERN YELLOW PINE.

(Adopted and Copyrighted by the
American Society for Testing Materials,
August, 1915.)

Southern Yellow Pine.- This term includes the species of yellow pine growing in the Southern States from Virginia to Texas, that is, the pines hitherto known as longleaf pine (Pinus palustris), shortleaf pine (Pinus echinata), loblolly pine (Pinus taeda), Cuban pine (Pinus heterophylla) and pond pine (Pinus serotina).

Under this heading two classes of timber are designated: (a) dense Southern yellow pine and (b) sound Southern yellow pine. It is understood that these two terms are descriptive of quality rather than of botanical species.

(a) Dense Southern yellow pine shall show on either end an average of at least six annual rings per inch and at least one-third summer wood, or else the greater number of the rings shall show at least one-third summer wood, all as measured over the third, fourth and fifth inches of a radial line from the pith. Wide-ringed material excluded by this rule will be acceptable, provided that the amount of summer wood as above measured shall be at least one-half.

DEFINITION FOR SOUTHERN YELLOW PINE-(continued)

The contrast in color between summer wood and spring wood shall be sharp and the summer wood shall be dark in color, except in pieces having considerably above the minimum requirement for summer wood.

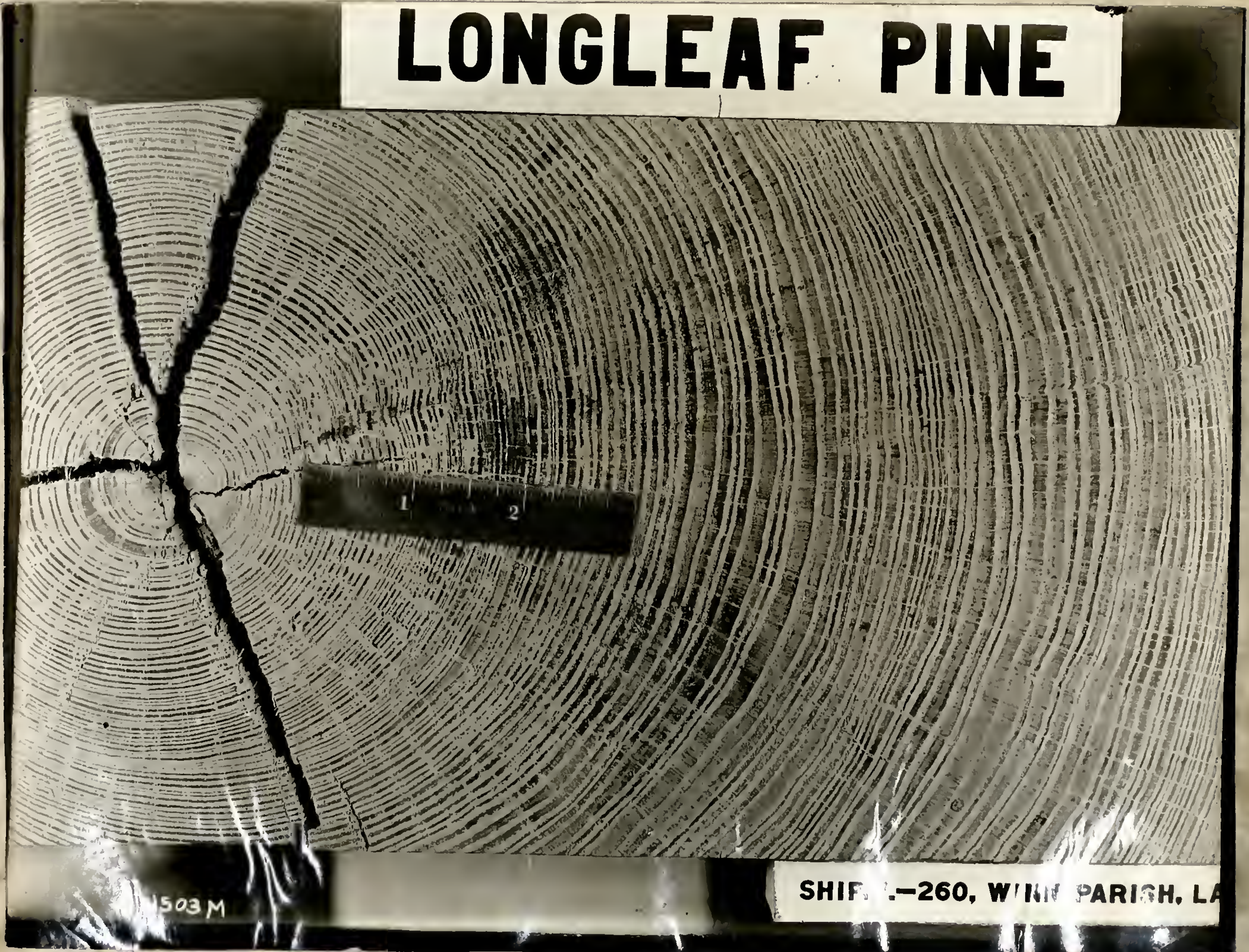
In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over 3 in. on an approximate radial line beginning at the edge nearest the pith in timbers over 3 in. in thickness and on the second inch (on the piece) nearest to the pith in timbers 3 in. or less in thickness.

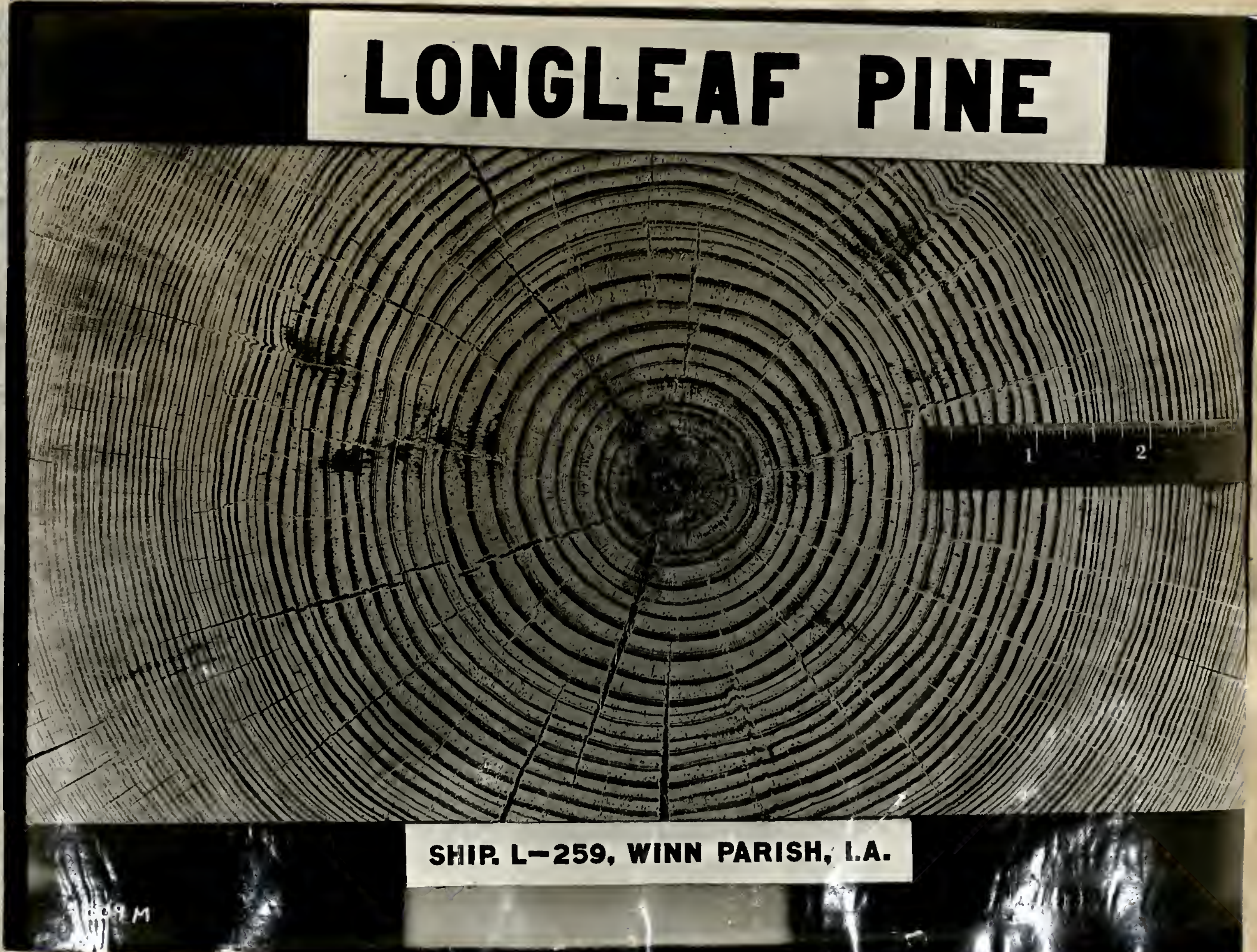
In dimension material containing the pith but not a 5 in. radial line, which is less than 2 by 8 in. in section or less than 8 in. in width, that does not show over 16 sq. in. on the cross section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5 in. radial line the inspection shall apply to the three inches farthest from the pith.

The radial line chosen shall be representative. In case of disagreement between purchaser and seller the average summer wood and number of rings shall be the average of the two radial lines chosen.

(b) Sound Southern yellow pine shall include pieces of Southern pine without any ring or summer wood requirement.

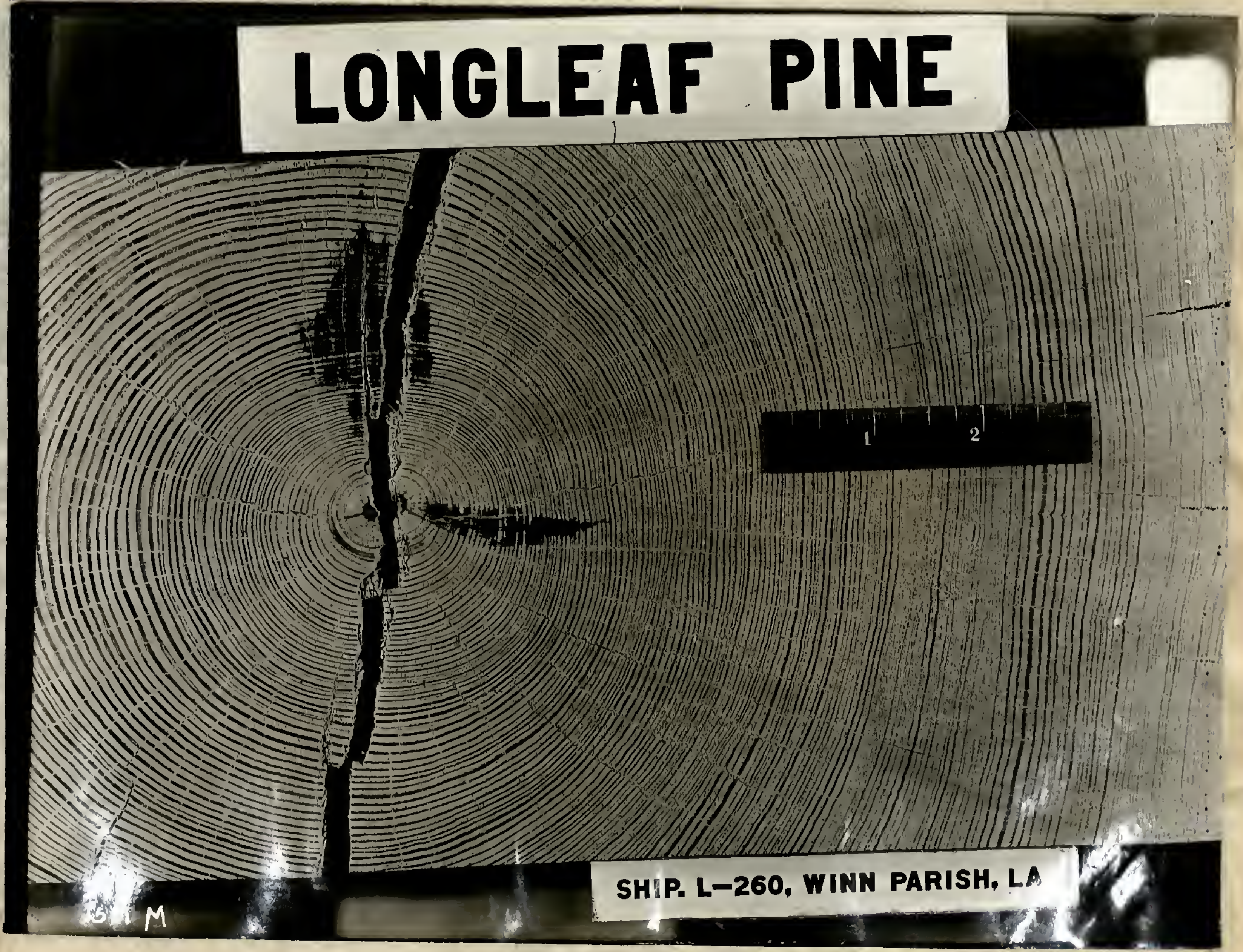
-:- -:- -:-

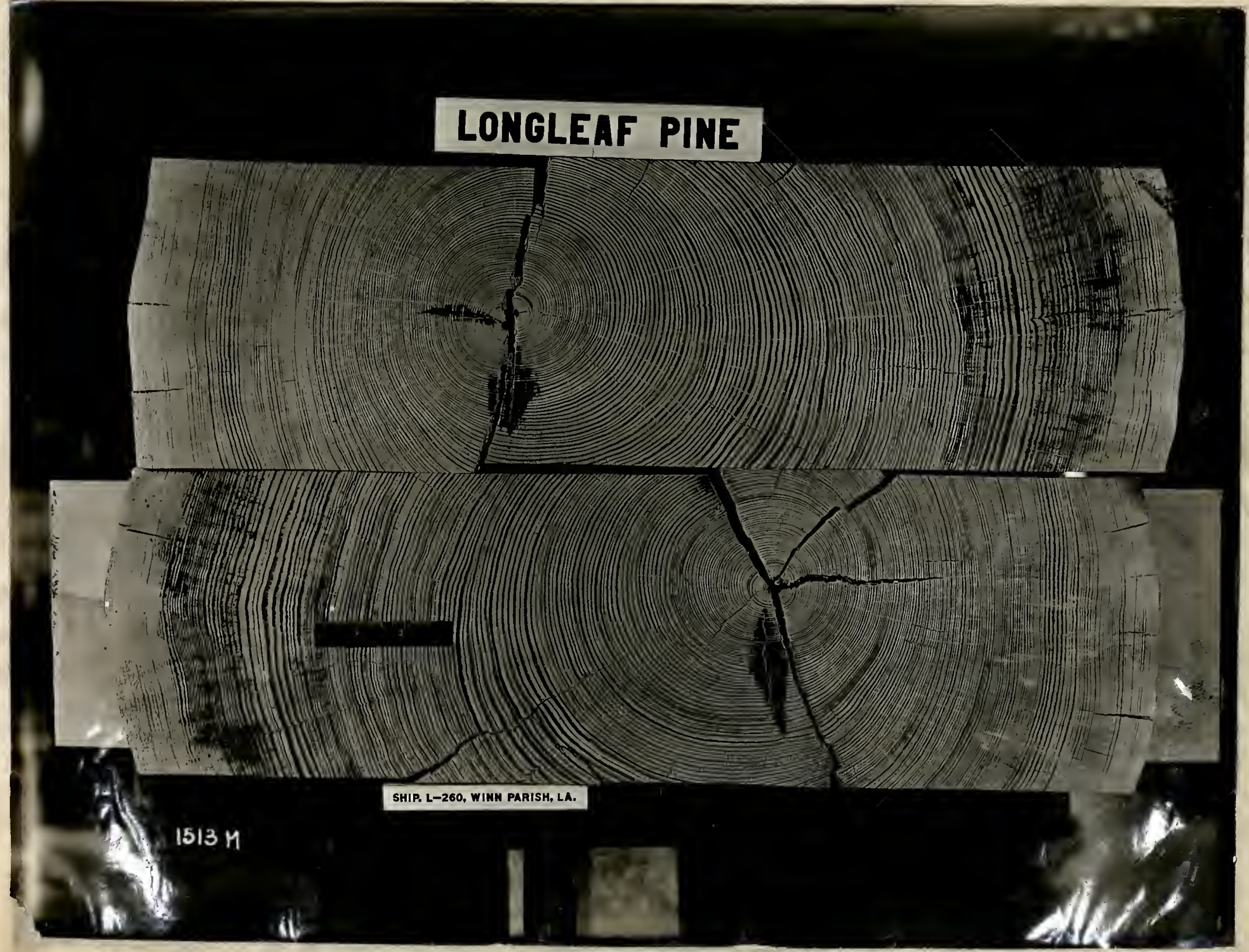

LONGLEAF PINE
1
2
1503 M
SHIP -260, WINN PARISH, LA

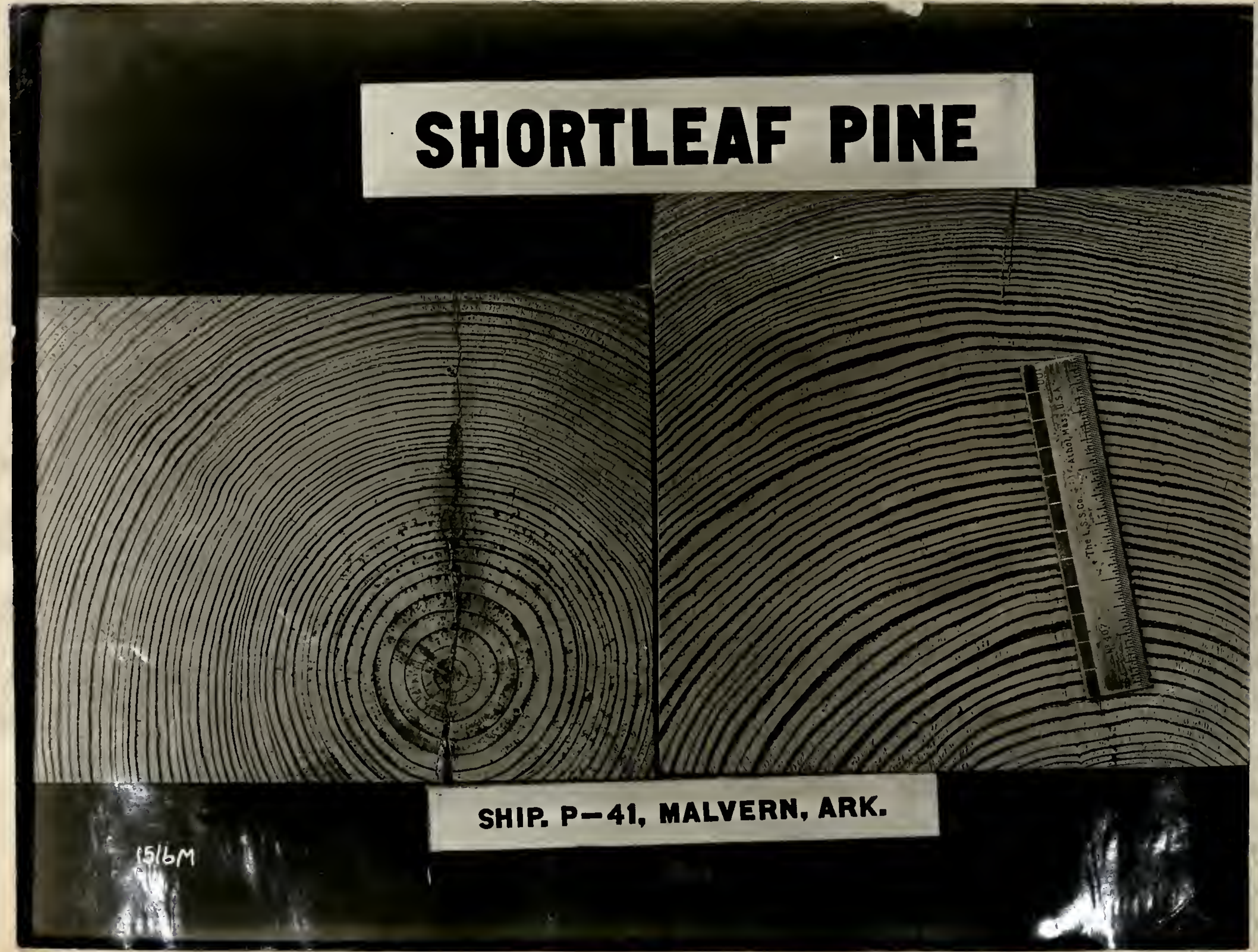


LONGLEAF PINE

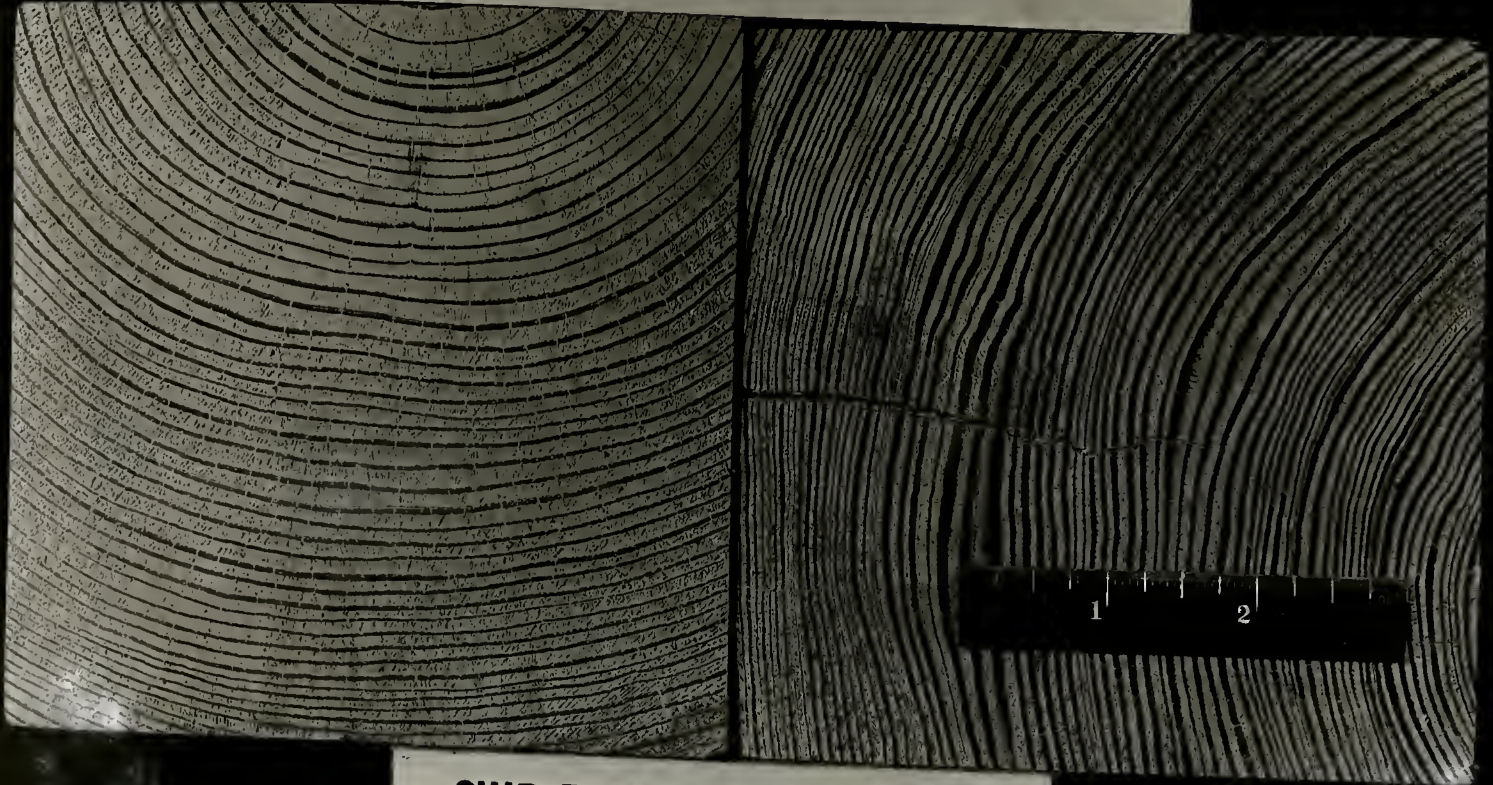
SHIP. L—259, WINN PARISH, LA.


LONGLEAF PINE
1
2
SHIP. L—260, WINN PARISH, LA
M


LONGLEAF PINE
SHIP. L-260, WINN PARISH, LA.
1513 M


SHORTLEAF PINE
The L.S.S.Co. Athol, Mass. U.S.A.
No 407
SHIP. P—41, MALVERN, ARK.
1516M

SHORTLEAF PINE



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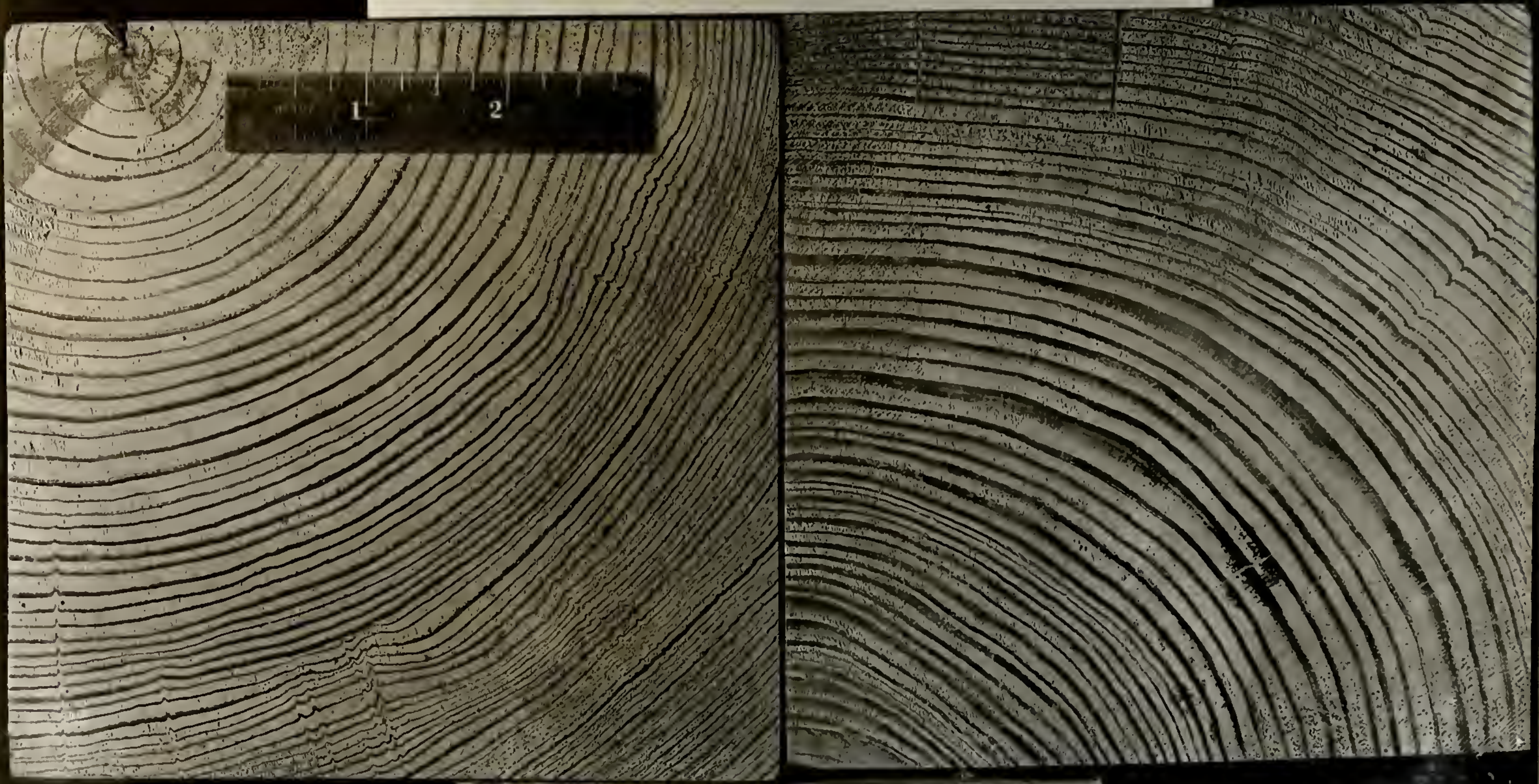
1517M

SHORTLEAF PINE



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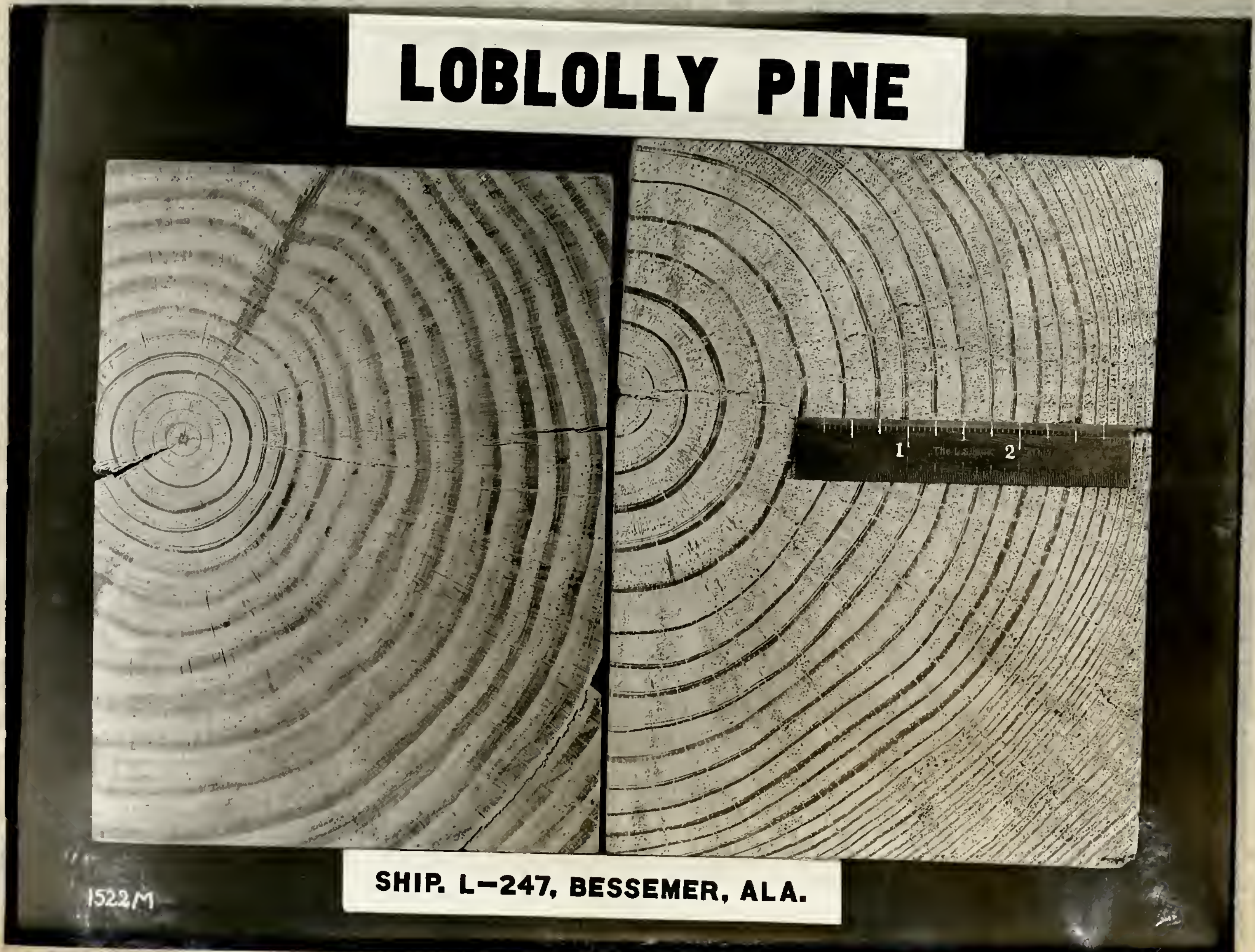
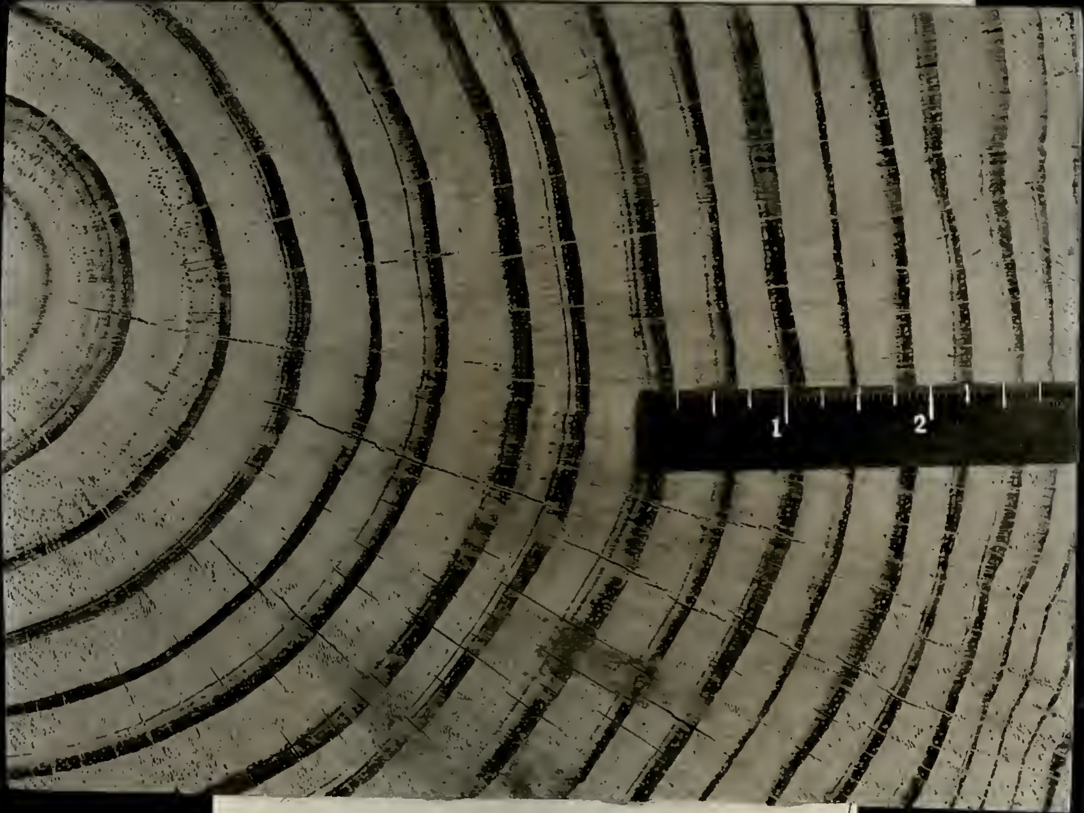
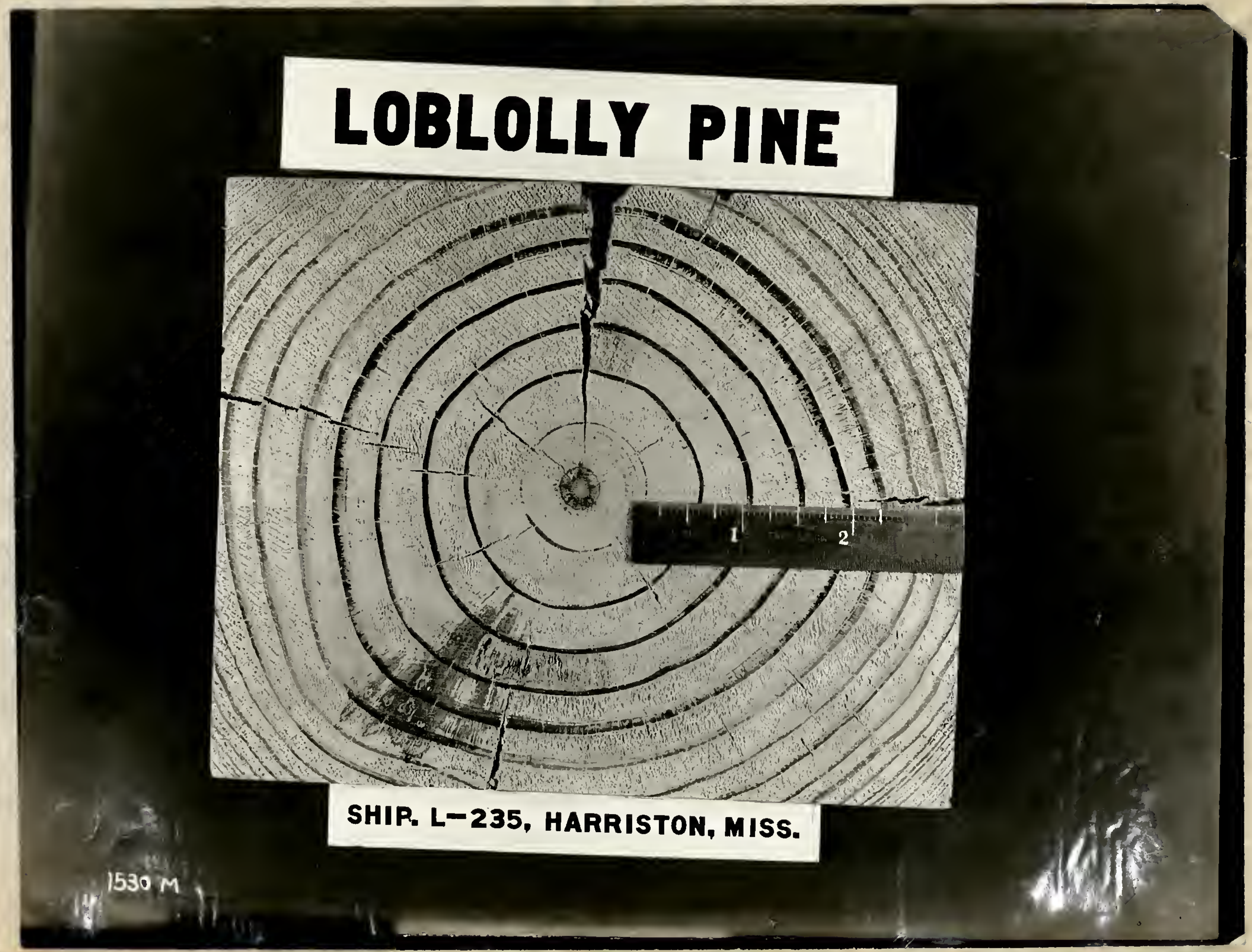

LOBLOLLY PINE
1
2
SHIP. L—247, BESSEMER, ALA.
1522M

LOBLOLLY PINE



SHIP. L—235, HARRISTON, MISS.

1524 M


LOBLOLLY PINE
1
2
SHIP. L—235, HARRISTON, MISS.
1530 M

(In this connection, general timber specifications were adopted by the various Yellow Pine Associations, to serve as a standard for specifying and grading timber. These specifications are herewith quoted:)

GENERAL TIMBER SPECIFICATIONS.

All timber except No. 1 Common must be free from defects such as injurious ring or round shakes, and through shakes that extend to the surface; unsound and loose knots, and knots in groups that will materially impair the strength. Seasoning checks and discolored sap shall not be considered defects in any grade.

KNOTS. - Knots shall be classified as round and spike in form, and for quality as sound, encased, loose and unsound.

A round knot is oval or circular in form.

A spike knot is one sawn in a lengthwise direction.

A sound knot is one solid across its face, is as hard as the wood which surrounds it, may be either red or black, and fixed by growth or position so that it will retain its place in the piece.

An encased knot is one whose growth rings are not intergrown and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain

its place in the piece, it shall be considered a sound knot; if completely intergrown on one face, it is a watertight knot.

A loose knot is one not held firmly in place by growth or position.

An unsound knot is one not as hard as the wood surrounding it, or one having a hole in it.

WANE. - Wane is bark on the corner of the piece, or the absence of the corner.

SHAKES. - Shakes are cracks appearing on the ends of timbers, either intersecting the annual growth rings or separating the same. They shall be classified as ring or round shakes and through shakes.

A ring or round shake is an opening between the annual rings.

A through shake is one extending from the region of the center to the surface of the piece or extending between two faces.

Shakes not hereinbefore described, unless known to have extensive penetration, shall not be considered a defect under this classification.

SIZES. - All rough timber, except No. 1 Common, must be full size when green. One-quarter inch shall be allowed for each side surfaced.

LENGTHS.- Standard lengths are multiples of two feet, eight to twenty feet, inclusive; extra lengths are multiples of two feet, twenty two feet and longer. When lineal average is specified, standard of lengths shall be multiples of one foot.

GRADES OF TIMBERS.

HEART TIMBERS.-All timber specifications, except "Merchantable" specifying heart requirements shall be considered as a special contract, and shall specify whether the heart requirements refer to cubical contents or surface measurements in each piece.

NO. 1 COMMON TIMBERS. May be either Dense or Sound Pine.

Common timbers, rough 4 x 4 and larger, shall be not more than 1/4 in. scant at any point when green, and be well manufactured and may have 1-1/2 in. wane on one corner one-third the length of the piece, or its equivalent on two or more corners; the wane measured on its face.

Timbers 10 x 10 in size may have 2 in. wane as above; the larger sizes may have wane as above in proportion to sizes.

The diameter of any one knot shall not exceed 2 in. in 4 x 4 to 6 x 6; 2-1/2 in. in 6 x 8 to 8 x 10; 3 in. in 10 x 10 to 10 x 12; 3-1/2 in. in 12 x 12 to 12 x 14; 4 in. in 14 x 14 to 14 x 16; 4-1/2 in. in 16 x 16 to 16 x 18. In sizes not mentioned the diameter of knots admissible will increase or decrease in proportion to the size of the timbers on same basis as above specified.

In determining the size of knots, mean or average diameter shall be taken, or the equivalent of the above in grouped knots at any one point. Shakes one-sixth the length of the piece, small unsound knots and a limited number of pin-worm holes, well scattered, are admissible.

SQUARE-EDGE AND SOUND TIMBERS. - May be either Dense or Sound Pine.

Square-edge and sound timbers shall be well manufactured and conform to the General Timber Specifications, admitting sound knots, and shall be free from wane.

MERCHANTABLE TIMBERS. - May be either Dense or Sound Pine.

All merchantable timbers shall be well manufactured and conform to the General Timber Specifications.

Sizes under 9 in. on the largest dimension, shall show two-thirds or more heart surface on one of the wide faces; sizes 9 in. and over on the largest dimension shall show two-thirds or more heart on both of the wide faces. When sticks are square the face showing the most heart shall govern the inspection on sizes under 9 in., and the two faces showing the most heart shall govern the inspection when 9 in. and over. Heart showing the full length, even if not two-thirds of the area as above, shall meet the requirements of this quality.

Wane not exceeding one-eighth of the dimension of the face and one-quarter of the length of the piece on one corner, or the equivalent on two or more corners on not to exceed ten per-cent of the pieces, shall be admitted. -:- -:- -:-

In this connection the influence of knots, checks, shakes and crooked grain on the strength of structural timber should be taken up, as it is a very important item in the design of timber structures. The most dangerous knots in a beam from the standpoint of strength are those on the lower side near the middle of the span. The next most dangerous knots are those on the upper side near the middle of the span. Knots along the center line of the height of the beam in general have but little effect on the strength.

Checks and shakes have a greater or less weakening effect according to their proximity to the center horizontal plane, due to their tendency to weaken the ability of the beam to resist horizontal shear. The effect of crooked grain on the strength, depends on its degree, and like knots it is most serious near the center of the beam on the lower side.

STEEL.

Steel is used in certain types of mill buildings, for floor girders, columns, post caps, lintels, etc. Where floor loads are heavy and spans long, or where headroom is an important factor, steel girders are often used instead of timber girders. This was especially true several years ago when the cost of steel was comparatively low and delivery certain.

Where framing has to be provided to support masonry walls, or where exposed to weather, steel columns and beams are used, both to reduce size of members and to give a more rigid, weatherproof and fireproof structure.

In standard mill construction wherever steel columns, girders and beams are used, they are fireproofed by encasing them in concrete, tile, brick or some other fireproof material.

The Chicago Building Ordinance requirements for fireproofing are very complete and illustrate the best practice along these lines:

(COLUMNS - EXTERIOR) -

(a) All iron or steel used as vertical supporting member of the external construction of any building exceeding fifty feet in height shall be protected against the effects of external change of temperature, and of fire by a covering of fireproof material consisting of at least four inches of brick, hollow terra cotta, concrete, burnt clay tiles, or a combination of any two of these materials, provided their combined thickness is not less than four inches. The distance of the extreme projection of the metal, where such metal projects beyond the face of the column, shall be not less than two inches from the face of the fireproofing; provided that the inner side of the exterior columns shall be fireproofed as hereinafter required for interior columns.

(COLUMNS - EXTERIOR)-continued.

(b) Where stone or other incombustible material not of the type defined in this ordinance as fireproof material is used for the exterior facing of a building, the distance between the back of the facing and the extreme projection of the metal of the column proper shall be at least two inches, and the intervening space shall be filled with one of the fireproof materials.

(c) In all cases, the brick, burnt clay, tile or terra cotta, if used as a fireproof covering, shall be bedded in cement mortar close up to the iron or steel members and all joints shall be made full and solid.

(COLUMNS - INTERIOR)

(a) Covering of interior columns shall consist of one or more of the fireproof materials herein described.

(b) If such covering is of brick it shall be not less than four inches thick; if of concrete, not less than three inches thick; if of burnt clay tile, such covering shall be in two consecutive layers, each not less than two inches thick, each having one air space of not less than one-half inch, and in no such burnt clay tile shall the burnt clay be less than five-eighths of an inch thick; or if of porous clay solid tiles, it shall consist of at least two consecutive layers, each not less than two inches thick; or if constituted of a combination of any two of these materials, one-half of the total thickness required for each of the materials shall be applied, provided that if concrete is used for such layer it shall not be less than two inches thick.

(c) In the case of columns having an "H" shaped cross-section or of columns having any other cross section with channels, or chases open from base plates to cap plates on one or more sides of the columns, then the thickness of the fireproof covering may be reduced to two and one-half inches, measuring in the direction in which the flange or flanges project, and provided that the thin edge in the projecting flange or arms of the cross sections does not exceed three-quarters of an inch in thickness.

(COLUMNS - INTERIOR)-(continued)

(c)-(continued). The thickness of the fireproof covering on all surfaces measuring more then three-quarters of an inch wide and measuring in a direction perpendicular to such surfaces shall be not less than that specified for interior columns in the beginning of this section, and all spaces, including channels or chases between the fireproof covering and the metal of the columns, shall be filled solid with fireproof material. Lattice or other open columns shall be filled completely with approved cement concrete.

(BEAMS, GIRDERS AND TRUSSES - COVERINGS OF.)

(a) The metal beams, girders and trusses of the interior structural parts of a building shall be covered by one of the fireproof materials hereinbefore specified so applied as to be supported entirely by the beam or girder protected, and shall be held in place by the support of the flanges of such beams or girders and by the cement mortar used in setting.

(b) If the covering is of brick, it shall be not less than four inches thick; if of hollow tiles or if of solid porous tiles, or if of terra cotta, such tiles shall be not less than two inches thick, applied to the metal in a bed of cement mortar; hollow tiles shall be constructed in such a manner that there shall be one air space of at least three-fourths of an inch by the width of the metal surface to be covered within such clay coverings; the minimum thickness of concrete on the bottom and sides of the metal shall be two inches.

(c) The top of all beams, girders, and trusses, shall be protected with not less than two inches of concrete or one inch of burnt clay bedded solid on the metal in cement mortar.

(d) In all cases of beams, girders or trusses, in roofs or floors, the protection of the bottom flanges of the beams and girders and so much of the web of the same as is not covered by the arches shall be made as hereinbefore specified for the covering of beams and girders. In every case the thickness of the covering shall be measured from the extreme projection of the metal, and the entire space or spaces between the covering and the metal shall be filled solid with one of the fireproof materials, excepting the air spaces in hollow tile.

STEEL - (continued)

(BEAMS, GIRDERS AND TRUSSES - COVERINGS OF)-(continued)

(e) Provided, however that all girders or trusses when supporting loads from more than one story shall be fireproofed with two thicknesses of fireproof material or a combination of two fireproof materials as required for exterior columns in Section 625 of thie Chapter, and each covering of fireproof material shall be bedded solid in cement mortar.

Every modern mill constructed building has either built up steel post caps or cast iron caps. There are many varieties of steel post caps used. In general they consist of angles and plates riveted together to form a rigid member.

Lintels used are almost exclusively of steel and consist either of a rolled section or of a built up member.

The steel used in building construction are standard rolled sections and plates and is usually specified to conform with the requirements of the manufacturers' standard specifications.

CAST IRON.

Cast iron columns have been used very extensively in mill buildings. Their use at the present time is limited mainly to one story buildings, boiler rooms or other places where wood is not desirable or cannot be used. The requirements for fireproofing cast iron columns are the same as those for steel.

Cast iron post caps, column bases, wall bearing plates, etc., are used in a great many buildings of this type.

The cast iron used should be tough gray iron, free from injurious cold-shuts or blow holes, true to pattern and of workmanlike finish.

BRICK.

Bricks are more extensively used than any other building material, with the possible exception of wood.

Good brick is practically indestructible, as it is unaffected by action of the weather or by fire. Its desirability as a building material is based on the fact that it is easily handled and can be made into any size, shape and color.

It is comparatively cheap and can be obtained in almost any locality.

BRICK - (continued)

Brick is made of sandy clay, silicate of alumina, usually containing small quantities of lime, magnesia and iron oxide. We will not go into the details of manufacture of brick, sufficient to say that they are made by burning the clay to a proper temperature in a suitable kiln.

Building brick is divided into two classes:

(1) Common Brick.

(2) Face Brick.

Common brick in turn is divided into the following three classes:

(a) Hard or Arch Brick. This brick comes from the arch of the kiln, and its proximity to the fire makes it badly checked and warped. It is also hard and brittle, with the result that it cannot be used for any other purpose than for piers and foundations.

(b) Red or Well Burned Brick. This brick comes from the center of the kiln and is the best brick for construction purposes. It can readily be recognized by its metallic ring when struck.

(c) Salmon or Soft Brick. This brick comes from top of kiln and is usually underburned. It should not be used where heavy loads are to be carried.

Care should be taken not to rely too much on the color of the brick for the determination of quality, as that may be due to the presence or absence of iron, rather than to its burning.

(2) Face Brick is made by re-pressing soft mud bricks and is usually dry-pressed. The better grades of brick are made in molds and can be made of different sizes and colors.

The color of brick depends upon the presence or absence of iron, lime or magnesia. The dry pressed brick is colored artificially by mixing clays of different compositions or by the addition of mineral colors.

There are many varieties of face brick and they are usually specified by the manufacturer's catalogue number or by the price per thousand, the size and color to be selected by owner.

Requisites of good brick are:

(1) Sound, free from cracks, flaws, stones, lumps of any kind, and especially lumps of lime.

(2) Uniform in size, and true surfaces, square with each other, with sharp edges and angles.

(3) Burned to incipient vitrification throughout. Should not absorb more than 10% water, as the durability of brick depends a good deal upon its non-absorption of water.

CONCRETE.

In a mill constructed building, concrete is used mainly for foundations, footings, exterior walls below grade, basement floors and occasional fireproofing of steel.

The mix of concrete used will depend upon the nature of the load it has to carry and varies in the different parts of the building. The foundation mix will depend upon the nature of the soil and the space available and under favorable circumstances will be of 1:3:5 mix.

When footings and foundations are heavily reinforced a 1:2:4 mix is used. The mix for basement floor usually consists of 1:3:5 concrete for the body of the floor and 1:2 for the finish surface.

The cement used in the concrete should be of an approved brand of American Portland Cement, tested to meet the requirements of the American Society for Testing Materials.

The sand should be clean, sharp torpedo sand, free from loam and vegetable matter.

The stone used should be either limestone screenings, free from dust, or clean washed gravel. In either case it must be of size to pass a three-fourths inch ring.

Concrete should be well mixed with enough water added to give it a consistancy known as "wet mix".

No attempt is here made to go into the details of concrete construction, as that does not come within the scope of this paper.

METHODS OF CONSTRUCTION.

WALLS AND FOUNDATIONS.

In designing any building, the question of walls and foundations is a very important one and must be thoroughly investigated before a final decision is reached. This is especially true of a mill building, where walls perform definite structural functions, as well as enclosing the building.

Walls are constructed of a great number of materials, the most prominent among them being brick, stone, concrete, tile, sheet metal on wood, etc. The kind of foundation for walls depends on the bearing power of the soil, the load carried by the walls and the drainage condition of the site.

There are varied opinions as to the amount of live load from the floors of the buildings carried by the footings. Some designers allow fifty per cent. of this load to be carried by the footings, while others allow different amounts, depending upon the ratio of the live load to the dead load of the building. The Chicago practice is to allow a sliding decrease in the percentage of live load transmitted to the footings, commencing with eighty five per cent. at the top story and decreasing by five percent. for each lower story, until fifty percent. is reached.

METHODS OF CONSTRUCTION.-(continued)

WALLS AND FOUNDATIONS-(continued)

The bearing power of the soil depends upon its composition, the thickness of the various strata, and its drainage. Of the soils most often encountered in ordinary foundation work, are rock, hard pan, blue clay, yellow clay, sand. and a mixture of any of these substances. The bearing power of the soil may be determined by tests, but the more common method employed by the experienced designer is to determine by inspection. This is done by either taking borings and sampling the soil every foot, or by digging test pits and noting the formation of the strata and other physical properties of the soil.

The average allowable safe bearing values of soils are:

Rock....................	10 to 200	tons	per	square	foot
Gravel, compacted........	8 to 10	"	"	"	"
Sand,clean and compacted.	4 to 6	"	"	"	"
Clay on thick beds, always dry.............	4 to 6	"	"	"	"
Clay on thick beds, moderately dry.........	2 to 4	"	"	"	"
Sand, clean and dry......	2 to 4	"	"	"	"
Dry earth................	1 to 2	"	"	"	"

Where soil is of such nature that it is unsafe to carry heavy building loads, wood or concrete piles, grillage oe caissons are used. Their bearing powers are determined by actual tests or by calculations, Wooden piles are usually calculated by the following formula (Engineering News):

$$P = \frac{2\ wh}{S \quad \frac{1}{10}} \text{ for steam hammer.}$$

$$P = \frac{2\ wh}{S \quad 1} \text{ for drop hammer.}$$

In this formula : S = set in inches.
h = fall in feet.
w = weight of hammer.
P = safe load in pounds.

Concrete piles are divided into two general classes, viz., pre-molded and cast in place. Their bearing value is determined by test piles, but in no case should the compression on such piles exceed the allowable unit compressive stress of concrete.

Caissons are used to transmit heavy building loads to solid rock or hard pan and are figured in a similar manner.

In proportioning footings, extreme care should be taken to prevent unequal settlement of different parts of building. Mere adherence to formulas will not always give a good foundation design. The designer must have the entire

building in mind and must develop a certain sense of proportion to guide him in his design.

In localities subject to freezing temperatures, footings must be carried below frost line. The depth of this frost line varies with the climatic conditions and in this part of the country it is safe to figure four feet six inches below grade for the frost line.

All exterior walls below grade are considered foundation walls. They are built of concrete, rubble stone masonry, and sewer or paving brick. For large buildings, concrete foundation walls are used almost exclusively. A properly designed concrete wall should have a certain amount of steel reinforcement to take care of temperature stresses and also to furnish a tie to the footings.

Rubble stone masonry is used for foundation walls of smaller buildings or where the loads are not excessive. They are built by laying up stone of different sizes in cement mortar.

Sewer or paving bricks are sometimes used for foundation walls, where it is desirable to have basement walls of good appearance. They are always laid up in cement mortar.

METHODS OF CONSTRUCTION-(continued)

WALLS AND FOUNDATIONS-(continued)

All foundation walls must be waterproofed to prevent seepage of surface water into the building. There are many kinds of waterproofing methods used, some added to the concrete during mixing, and others applied as a membrane on the inside or outside of the wall. Among integral waterproofing compounds used are hydrated lime, colloidal clays, and a great number of special waterproofing compounds placed on the market by paint and chemical companies. Their value can only be determined by actual usage and one should exercise all possible care in selecting them.

The membrane waterproofing consists either of a heavy coat, (1/4" to 1/2") of rich cement plaster, applied on the inside or outside of wall, or on both sides in extreme cases, or of several coats of dry roofing felt placed on the outside of wall and well mopped with hot tar or asphalt. There are a number of iron oxide paints, applied on the outside of the wall, the theory being that iron rusts and fills in the pores of the wall. If membrane waterproofing is used, it must be carried over the top of the footing, to prevent seepage through this source.

The exterior walls of mill buildings are either of piers and curtain wall type, or straight bearing walls, or a combination of both. The pier and curtain wall construction consists of heavy piers, proportioned to take the floor loads from the girders and the weight of the walls.

Their size will depend upon the materials entering into their construction. The curtain walls are of minimum thickness, usually eight inches in one story buildings, and twelve inches for multiple story buildings.

The advantages of this type of construction for tall buildings with heavy loads are, its reduced cost and large percentage of window space. However, there are certain features in this construction which make it not very desirable. They are; the large pier projections breaking up the floor space at walls, where it is most valuable, and the loss of radiation through thin curtain walls. Special care must be taken during construction to securely tie the curtain walls and piers to the framing of the building.

Where straight bearing walls are used, they are designed to take their share of the dead and live loads of the building. Their thickness will depend upon the number of stories, the loading, the size of spans and the materials used. The building codes of most municipalities have established the minimum thickness of walls to be used. They are usually figured very liberally and present an excellent check on the designer's work. To some industries the straight unbroken wall is of advantage and, although more expensive in many instances, is preferred to the curtain wall and pier construction. This is well illustrated in shop buildings, where benches are located along walls, under windows.

METHODS OF CONSTRUCTION-(continued)

WALLS AND FOUNDATIONS-(continued)

Brick is almost universally used for exterior wall construction, although other materials are used when conditions warrant. Where brick walls are used, it is equally important to use good mortar as well as sound brick. The brick should be hard, well burned common brick, free from defects. Mortar should be of good binding quality. The strength of the wall is governed by the quality of the brick and mortar used. There are several kinds of mortars used, viz; cement mortar, consisting of a mixture of sand and cement, with not more than 10% of lime; lime tempered mortar, a mixture of lime and sand, with about 10% of cement. Lime mortar is composed of sand and lime.

In curtain wall and pier construction, where heavy loads are carried and the size of pier is restricted, the piers should be laid up in cement mortar. Cement mortar is more expensive as it requires more care and labor in laying. Where space is of no great importance, it is found that piers laid up in lime tempered mortar will reduce the cost of the building.

Straight bearing walls are usually laid up in lime tempered mortar. Walls subject to excessive or variable loads should be laid up in cement mortar. Walls above roof and walls below grade should always be laid up in cement mortar.

METHODS OF CONSTRUCTION-(continued)

WALLS AND FOUNDATIONS-(continued)

The Chicago Building Code gives the following requirements for masonry:

ALLOWABLE STRESSES AND SPECIAL REQUIREMENTS FOR MASONRY.

(a) Allowable stresses in pounds per square inch on plain concrete and stone masonry shall not exceed the following:

	Lbs.
Coursed rubble Portland cement mortar	200
Ordinary rubble Portland cement mortar	100
Coursed rubble lime mortar	120
Ordinary rubble lime mortar	60
First-class granite masonry, Portland cement mortar	600
First-class lime and sandstone masonry " " " "	400
Portland cement concrete 1-2-4 mixture machine mixed	400
Portland cement concrete 1-2-4 mixture hand mixed	350
Portland cement concrete 1-2½-5 mixture machine mixed	350
Portland cement concrete " " " mixture hand mixed	300
Portland cement concrete 1-3-6 mixture machine mixed	300
Portland cement concrete 1-3-6 mixture hand mixed	250
Natural cement concrete 1-2-5 mixture	150

(b) Allowable compression in pounds per square inch on brick masonry shall not exceed the following:

No.1 paving brick, 1 part Portland cement, 3 parts torpedo sand	350
No.2 pressed brick and sewer brick, mortar same as referred to above	250
No.3 hard common select brick, Portland cement mortar, same as referred to above	200
No.4 hard common select brick, 1 part Portland, 1 lime, 3 sand as referred to above	175
No.5 common brick, all grades, Portland cement mortar	175
No.6 common brick, all grades, good lime and cement mortar	125
No.7 common brick, all grades, natural cement mortar	150
No.8 common brick, all grades, good lime mortar	100

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FLOORS.

In the design of any floor system, the following must be considered:

(1) Columns.

(2) Girders.

(3) Joists and rough floors, or

(4) Laminations.

(5) Finished floors.

There are three standard types of floors used in mill construction. They are:

(a) Joists resting on top of girders.

(b) Joists hung from girders by means of metal stirrups

(c) Laminated floors.

In girder and joist construction the most widely used method is where the joists rest directly on top of girders. This is the cheapest and simplest way of supporting floors. This however, is offset by the increased height of walls where definite story clearances are required. It leaves exposed all sides of girders, forming a dust collector. It somewhat obstructs distribution of light from windows and very often results in warped floors due to uneven shrinkage of joists and girders.

Where joists are suspended from girder by means of metal stirrups, the story heights may be reduced, yet there are other features which make this type not altogether desirable.

In the first place, the resulting floor system is not very rigid. Second, where the top of the joists and girders are flush, there results an uneven floor due to shrinkage. There is also a serious objection to this type from the point of view of fire protection, as in case of fire, the stirrups will readily yield and drop the floor.

In either case, the rough flooring on top of the joists will consist of 2-5/8" x 5-1/2" dressed and matched yellow pine boards laid across joists.

The laminated type of flooring consists of placing planks on edge securely spiked together and resting on girders. This construction gives a continuous ceiling surface free from all obstructions allowing the use of a reduced story height. It also reduces the cost of all piping and especially the cost of the sprinkler system. Since laminations are of an even thickness, the shrinkage will be uniform, which is a very important item in factories and shops having machinery and shafting resting on floors or suspended from ceiling.

COLUMNS.

The columns in a mill constructed building may be either of wood, steel or cast iron. Where metal columns are used, they must be properly fireproofed as described elsewhere in this paper. Since this makes the cost of such construction very high, it is seldom used and therefore we will limit our discussion to timber posts.

The size of the posts will depend upon their spacing, loading and story height. In no case however, shall columns of less cross section area than 100 square inches be used, the theory being that a column of this size will not burn out readily, thus preventing the collapse of the floors.

The timber used should be sawed true and square at right angles to its axis, and should have solid bearing on bases and caps. It is customary to round or chamfer all edges of posts and bore holes vertically through center of column to meet holes bored horizontally at top and bottom.

There are many opinions as to the advisability of boring holes through columns. Some maintain that these holes prevent undue checking and cracking of columns due to drying out, and assist in ventilating and drying of column. Others maintain that these holes are detrimental to the life of the structure as they furnish an easy and quick means of travel of dry rot fungii.

METHODS OF CONSTRUCTION-(continued)

COLUMNS-(continued)

From our personal experience we would recommend that holes be bored in timber posts unless there are very good reasons to the contrary. This opinion is based on observation on the behavior of such posts in buildings.

Where column bases are below floor or where columns rest directly on masonry, the lower portions of such columns should be treated with some wood preservative such as creosote.

Where timber columns are used, their load is distributed to the footings by means of bases. These bases are made either of stone, steel or cast iron.

Stone bases consist of a solid piece of limestone, set in cement mortar, on top of footing, with upper face planed to receive post and sides beveled for good appearance. They usually project a few inches above floor. This type of base is very seldom used at the present time.

Steel post bases are made of heavy steel plates, designed of sufficient thickness to take the shear and moment, and of size to distribure the column loads to masonry. There is usually a dowel passing through center of plate into masonry and projecting from two to five inches into column. This is done in order to anchor posts during construction, before the floor loads are applied.

METHODS OF CONSTRUCTION-(continued)

COLUMNS-(continued)

The most commonly used bases for posts are made of cast iron. They consist either of a solid plate, notched out to receive post, or of a special shoe, made of top and bottom plates and vertical webs. A two-inch hole is cored through the center for grouting. Good practice requires that the upper part of the shoe project from one half to two inches above floor, to prevent water reaching the ends of columns. The drawings accompanying this paper contain a detail of this type of shoe.

The load from girders is transferred to column by means of post caps, of which there are three standard types, namely, wood bolsters, cast iron caps, and built up steel caps.

Wood bolsters are designed to take the reaction from girders and are made of yellow pine or oak. They are usually of the same cross section as the girder, and their length varies with the load and span. They are fastened to post by means of drift bolts or lag screws. Bolsters do not make for a rigid structure, and cause uneven settlement of floors due to their shrinkage, hence are not used to a great extent at present.

Cast iron post caps consist of a casting shaped to fit columns and to receive girders. The top plate is supported by ribs and some types have lugs to receive girders. The uncertainty of the strength of cast iron necessitates the use of heavy sections, and the possibility of cracking due to shock or vibration make this construction not very desirable.

There is also this danger during a fire, when a stream of water is applied.

The modern post cap is made of steel angles and plates riveted together to form a rigid connection between girder and post. The thickness of the angles and plates used will depend upon the load carried and the projections, while the size will be governed by the cross section of post and girder. The angles under girders should be heavier than the angles on the other two sides. All rivets coming through top plateare countersunk, to furnish an even bearing for column and girders. Post caps for roof girders are made of angles alone, without plates.

There are a number of patented steel post caps on the market, built either of plates and angles, or of bent plates, shaped to form caps. They are all variations of the same principle and their choice will depend upon the individual preference of the designer.

METHODS OF CONSTRUCTION-(continued)

GIRDERS.

There are two kinds of girders used in a modern mill constructed building, viz; steel and wood. Steel girders consist of one or two standard rolled sections, properly fireproofed as hereinbefore described. When two sections are used, they are connected with cast iron separators and are bolted to post caps.

Holes should be left in the top flange of such girders for spiking joists where same rest on top of girder. Where laminated floors are used, a wood plate is bolted to top of steel girder to receive the laminations. Steel girders are more expensive than wooden girders and are used only where long spans are required, and where loads are heavy.

Wood girders are made of one or more sections, cut and framed to proper lengths. Where one section is used, the girder rests directly on post caps and is fastened by lag screws. If two or three sections are used, they are framed around posts and are bolted together to act as one. The sections are separated by 7/8 inch to 1 inch strips of wood placed about five foot centers, and all bolted together at these places by 3/4 inch or 1 inch bolts having heavy malleable iron nuts and washers. The separators should be about four inches wide and of a different wood than the girders - usually of maple or oak.

METHODS OF CONSTRUCTION-(continued)

GIRDERS-(continued)

Where wood girders frame into masonry walls, their ends must not come in contact with the masonry. Steel or cast iron wall bearing plates are used to distribute the load to the masonry. The side and end of girders coming in contact with masonry must be protected either by cast iron boxes or by coating the ends with a damp-proof paint. The ends of girders are "fire-cut", that is, they are cut so that in case of fire the falling girder will not pull the wall with it.

It is customary to give the girders from eight to twelve inches bearing on masonry, depending upon the load; but as it is not advisable to cut a slot of this depth, the wall is corbeled out about six inches to receive girders, thus requiring a smaller cut into wall. These corbels should be built solidly, not less than two feet six inches in height, and should always be laid in cement mortar. The brick projections should never be more than one inch per two bricks.

Steel bearing plates are used mostly for steel girders, while cast iron plates are used where girders are of wood. The cast iron plates have lugs on lower side to anchor masonry, and on upper side to anchor girder. Where wood girders meet over post caps, steel straps are used to join them, thus tying the whole structure together from wall to wall. These straps consist of steel plates 1/4 inch to 3/8 inch thick, and about 3 feet long, with about eight 5/16 inch holes for lag screws. A strap should be placed on each side of girder.

JOISTS.

Only Wooden joists are used in mill constructed buildings, They should be not less than seventy two inches in cross section. Where joists rest on walls, cast iron bearing plates are used, of a pattern similar to that used for girders.

The wall ends of joists are also treated in a similar manner. Where corbels are used, they are made not more than four inches in depth.

Where joists rest on top of girders, full bearing must be given. Usually a space of about one inch is left between the ends of opposite joists meeting over the girder.

Some designers fasten the joists to girders by means of small angles spiked to both girder and joist. This is not very often done, as there is no danger of joists tipping over.

Joists meeting over girder are tied to each other by means of steel straps about 1/4 inch in thickness, two inches in width and from two feet to two feet six inches in length.

ROUGH FLOORS.

Rough flooring is made up of boards, 2-5/8 inches by 5-1/2 inches, Tongued, grooved and beaded, surfaced one side. These are laid over joists and nailed with twenty penny nails, using two nails over each joist. Boards should not break joints, except over joists.

METHODS OF CONSTRUCTION.-(continued)

LAMINATIONS.

Laminations consist of two or three inch plank, six to eight inches in depth, placed on edge directly over girders, thus eliminating joists. Since timbers are cut to standard lengths, spans must be so arranged as to prevent unnecessary waste of timber. The laminations should be dressed on top and bottom only, and not on sides. This is done in order to make certain that a space for free circulation of air be left between each plank, to assure proper drying of the lumber.

Laminations are spiked to each other with forty penny nails, every twenty four inches. When laminations meet over girder, a space of one inch should be left between ends, to secure free circulation of air and to prevent transfer of vibrations from one panel to the other.

Every eighth lamination should break joints in the center of panel, thus making a continuous tie between opposite walls of building. There has been a good deal of discussion on the subject of breaking joints in laminations, some designers advocating alternating joints at quarter points, some every fourth lamination at the center, and a good many other combinations. There is no cut and dried rule as to breaking of joints, and the personal experience of the designer will govern. Suffice it to say that the less joints outside of girder, the less vibration will be transmitted from panel to panel.

Where the ends of laminations bear on masonry walls, the walls are corbeled out four inches, and a wooden plate about three inches thick is placed on corbel and is securely anchored to wall by means of strap anchors. The laminations rest on top of these plates and an inch joint is left between ends of lamination and wall for possible expansion. Longitudinally, the laminations do not get any bearing on walls and a construction joint of three inches is usually left, to be filled in when the roof is on. Laminations should be anchored to walls with pins and strap anchors, every four feet.

FINISHED FLOORS.

On top of rough plank flooring or laminations, a layer of two or more thicknesses of building paper is laid, to prevent moisture penetration. On this the finished floor is nailed.

This flooring usually consists of 13/16 inch factory common maple, tongued and grooved, and laid with joints perpendicular to the joints of rough floor, or diagonally. Two thicknesses of maple flooring, or 1-5/8 inch thick stuff is used, where the floors are subject to great wear. Care should be taken to have maple absolutely dry and the floor free from moisture.

When laying maple flooring, joints should be left at walls and posts, to allow for expansion due to dampness, during construction. This is filled in after the building is completed, and a quarter-round nailed to cover these joints at walls and columns.

METHODS OF CONSTRUCTION-(continued)

ROOF.

The essential requirements of a good roof are resistance to wind, rain, snow, ice, heat, cold and other action of elements. A mill roof usually consists of two parts, namely the roof boards and roofing. Roof boards should be not less than 2-5/8 inches thick, tongued, grooved and dressed on both sides. Roof framing should be arranged to give roof proper pitch for drainage. This pitch will depend upon the nature of the roofing and in no case should be less than 3/8 inch to the foot.

There are several methods of arranging roof framing to drain roof properly. One way is to place each row of roof girders on different elevations by means of varying the height of columns in each row. Another way is to have all girders on the same level and blocking up under joists. A third way is to build roof framing level and obtaining slope by means of wooden saddles or cinder fill. In no case should girders be sloped, as this produces a very unstable roof.

There are a number of roof coverings used for mill roofs, such as tar and gravel; prepared roofing, tin, galvanized iron, slate, etc. The most generally used roofing for this type of building is tar and gravel or composition roofing.

METHODS OF CONSTRUCTION-(continued)

ROOF-(continued)

The specifications in part 2 of this paper will give a detailed description of laying this roofing. Special care must be taken to cover joints at walls, which is accomplished by turning roofing up about eight inches and using sheet metal flashing and counterflashing properly secured to wall and jointed to roofing.

DETAILS OF DESIGN.

In considering the design of a building, the following items should be given careful attention:

(1) Use or occupancy.
(2) Size.
(3) Location.
(4) Loading.
(5) Special Requirements.

The purpose for which the building is to be used will determine the kind of building to be erected. Different industries will require different housing conditions, and will determine such items as the story height, size of panels, amount ot light, ventilation, etc.

The size of the building will depend upon the nature of the occupancy, whether it is to be used for manufacturing purposes or as a warehouse. If the building is to be used for manufacturing purposes, its size will be determined by the number and kind of machinery, the number of people employed and the process of manufacture.

Where the process of manufacture is continuous and the machinery used, very heavy, a one story building is desirable. On the other hand, where the process of manufacture is in well defined stages and machinery used not very heavy, a multiple story building is preferable.

The amount of light and ventilation required will also be a factor in determining the size of the plant.

DETAILS OF DESIGN-(continued)

Where buildings are used for warehouse purposes, their size will be determined by the amount and nature of merchandise stored. Bulky merchandise will require larger buildings with increased story heights, while heavy and compact commodities will allow the use of smaller buildings with lower story heights.

The cost and availibility of land will often be the deciding factor in determining the size and height of the building. This brings up the question of location.

The choice of location is governed by the amount of land required, the value and availibility for future extensions, the amount of labor in the vicinity, the source of power, the supply of raw material, the shipping facilities and the proximity of the market.

In designing the structural end of a building, the load per square foot to be carried on every floor must be determined. This is found by investigating the probable contents of the building, its weight and distribution. Where definite data of loading is not available, the appended table will serve as a guide in determining the required strength of floors.

When the kind and nature of the contents are determined, the spans can be decided upon. The spans will also depend upon the size of girders and joists to be used, and upon the utilization of the full strength of materials.

In timber framing, the standard commercial lengths should be employed. Column spacing is seldom limited by the size of column proper, as timbers of sufficient size to carry the floor loads may be easily obtained. As a rule, timber posts will not be of excessive size, except possibly in the basement, where space is not very valuable.

The framing of the building will depend upon the above mentioned conditions. The choice of materials for framing will be governed by the availibility and cost of such material.

There are no well defined rules for the selection of materials, and the acquaintance of the designer with the market conditions, its supply and prices, will be of great value.

DETAILS OF CONSTRUCTION.

After the Engineer has decided upon the materials to be used in the construction of the building, he must direct his attention to the building as a whole, in its relation to maintenance, upkeep, fire protection, etc., etc. Frequently a building of a high initial cost will have a very low depreciation factor and hence will be more economical than a cheaply constructed building requiring constant repairs. Close attention to the following items will materially aid in reducing the cost of maintenance of a building.

The life of a mill constructed building depends mainly upon the durability and preservation of its timber framing. It is necessary to understand thoroughly the conditions which bring about timber decay and the methods whereby this can be prevented or retarded. This will depend upon the kind and quality of the timber used, the conditions under which the timber is placed in the building and the condition under which the structure is maintained.

Decay of timber is due to the growth of wood destroying fungi within the tissues of the wood. There are two stages in the life of the wood destroying fungi:

(1) The vegetative stage, consisting of thread-like branches or filaments, named mycelium.

(2) The fruiting stage, which is a compact mass of mycelium, taking a definite form on the surface of the decaying timbers and serving for the production of spores and hence, the propagation of the species. The chemistry of the rotting process is not well known at the present time. Sufficient to say that the fine mycelium fills up the pores of the wood and the cells of the pith rays, as well as bores through the walls of the wood elements, thereby causing general disintegration.

The essential conditions for fungi development are:

(a) Sufficient moisture.

(b) A small amount of air within the wood.

(c) A suitable temperature.

A suitable amount of moisture is the most important factor in the decay of timber. In order to thrive, the different fungi require different amounts of moisture. These different degrees of moisture will develop various forms of decay, of which the most commonly known are, DAMP ROT and DRY ROT.

Damp rot is caused by a group of fungi known as members of the polyporous family. They require a large amount of moisture, and are particularly destructive in poorly ventilated basements. Since the question of damp rot is not very important in a well constructed mill building with proper facilities for drainage, we will confine this discussion to the causes and prevention of dry rot.

Dry rot is caused by a group of fungi known as "merulius lachrymans" and "coniophora". These fungi do not require a large amount of moisture and hence, are found in reasonably dry buildings.

The building timber may be infected with dry rot fungi either in the mill or yards where it is stored in the proximity of infected or diseased timber, in transportation, or during the erection of the building, where it is unduly exposed to the action of the elements, or while in the building, due to favorable conditions for the growth of the fungi.

Professor Humphrey, in his paper "Timber Decay and its growing importance to the Engineer and Architect", reviewing the conditions which favor the development of rot-producing fungi, says: "The principal sources of danger fall, roughly, under the six following heads:

(1) Placing non-durable timber in moist, ill ventilated basements or enclosures beneath the first floor, or laying sills in direct contact with the ground.

(2) Imbedding the girders and joists in brick or concrete without boxing the ends.

(3) Placing laminated flooring in unheated buildings in a green or wet condition.

(4) Covering girders, posts or laminated flooring with plaster or similar coating before thoroughly dried.

(5) General use of non-durable grades of timber in a green or only partially seasoned condition.

(6) Use of even dry timber of low natural durability in buildings artificially humidified to a high degree, as in textile mills.

A further element of danger lies in the use of timber infected during storage, or which has become infected through neglect after purchase and delivery."

In order to prevent rot in buildings, the first consideration is the use of timber of good quality, dense and sound in every respect, absolutely dry and seasoned before placing in building. Timber having a large percentage of sap wood should not be used as it is very susceptible to infection and decay. The question of rosin content as a factor in preventing the growth of fungi in timber has been widely discussed with the result that some authorities recommend the use of timber with 3 to 5 per cent of rosin.

The care of timber during the erection of the building is next to be considered. Even timber of good quality and well seasoned may lose its resisting power by undue exposure to the elements. If, however, the building is erected during a rainy season or during winter, artificial means must be employed to dry it out before it is occupied.

DETAILS OF CONSTRUCTION-(continued)

This is accomplished by enclosing the building and heating it to the highest temperature possible by the use of steam plant or by salamanders. Heating should be kept up for at least a week or ten days, depending upon the condition of the building. Care must be taken to properly ventilate the building while this heating is going on. As a matter of precaution any mill building should be treated in this manner regardless of the weather conditions during erection. The period of treatment need not be of more than three days duration under ordinary conditions.

The measures to prevent dry rot in the building should not be confined to its construction stages only, but should be continued during occupancy of the building. One of the most important considerations should be the ventilation of all portions of the timber framing. This is accomplished by proper design and construction, which will expose all timber to air currents and will insure proper circulation of air.

A sufficient number of air openings for direct ventilation or mechanical means of ventilation must be employed. Where the building cannot be properly ventilated due to the nature of the contents, the timber should be treated with a suitable wood preservative.

DETAILS OF CONSTRUCTION-(continued)

Another very important item in the prevention of dry rot is painting. A heavy coat of paint may accelerate or retard the rate of rotting, depending whether it prevents the wood from absorbing or giving up moisture. The condition most commonly met, in which paint causes rotting, is when it is applied to green timbers saturated with water. With dry, sound timbers which are to be placed in a moist atmosphere, a paint will prove beneficial in proportion to its waterproofing power. In ordinary building operations however, the timber is not well seasoned,and therefore a positive rule should be made not to paint, varnish, plaster or otherwise cover the structural timber of the building for at least two or three years after completion. If decorating is absolutely necessary, cold water paint or whitewashing may be permitted.

Timber which is infected with dry rot fungi, if properly seasoned, or if permitted to season in a comparatively dry room will not be destroyed from this cause. The fungi will become dormant and die, as they cannot grow except under conditions of high humidity.

FIRE PROTECTION.

There is no absolutely fire proof structure. No matter what the material used, it is subject to failure due to the action of fire and water. Therefore the problem of the engineer is to design a building as nearly fireproof as possible, with the least cost.

The well constructed mill building meets this requirement to a marked degree.

The building must be protected from damage by fire originating from outside sources as well as from fire within.

To protect the building from fires originating outside, the walls and roof of the building must be of noncombustible material and the windows and doors must be fire proof.

Walls should be made of stone, brick, concrete or tile. Tile, cinder concrete, and composition make for an incombustible roof although composition is not strictly fireproof.

There are two kinds of fireproof windows used, namely solid steel frames and sash and sheet metal frames and sash.

Solid steel windows consist of rolled steel shapes riveted or welded, with fins extending into wall on all four sides. Sheet metal windows consist of galvanized iron frames and sash riveted together. The thickness of the metal used will vary with the size of the window, and should not be less than #24 gauge.

The size of fireproof windows is usually limited by ordinance or requirements of the National or Local Boards of Underwriters.

FIRE PROTECTION-(continued)

In Chicago no fire window can be of size larger than 5'0" x 9'0", unless divisions of incombustible material is used. In either case the window opening must be protected by wire glass of standard thickness (1/8" to 1/4") or by electro-glazed prism glass. Sills and lintels must be of incombustible material. Doors must be either of steel or tin clad, and will be discussed later.

In order to retard and prevent fire from spreading from one portion of the building to another, the following construction features must be adopted.

(1) All interior partitions should be built of incombustible material.

(2) Large floor areas must be separated by fire walls of incombustible material.

(3) All stairways, elevators, and other shafts must be enclosed by incombustible walls.

(4) There should be no unprotected floor openings.

(5) All door openings should be protected by automatic fire doors.

(6) Sprinkler system and other fire fighting apparatus must be installed.

The interior fireproof partitions are built of either hollow tile, metal lath and plaster, gypsum, and macholite.

FIRE PROTECTION-(continued)

The most commonly used partition is made of metal lath and plaster, about two inches in thickness, and consisting of steel channel studding covered on both sides with metal lath and plastered.

The area of floor which may be built without dividing fire walls is usually a matter of official regulation. The Chicago Building Ordinance allows a floor area of not more than 12000 square feet in an unsprinkled mill building and 16000 square feet in a sprinkled building. Where there are no official restrictions, the placing of fire walls will depend upon the type of construction and the nature of occupancy. As a general rule, it is advisable to separate by fire walls portions of building where fire hazards differ, but in no case should the undivided floor area exceed 16000 to 20000 square feet. These walls are usually built of brick and should be of the same thickness as the outside walls. They should extend from foundation clear through, and about three feet above roof.

The walls enclosing stairways, elevators and other shafts, are built of hollow tile or brick and should completely separate such shafts from the balance of the building. The stairs should be built of incombustible material although wooden stairs of heavy framing are permitted in mill buildings. Exterior stairways such as fire escapes should always be made of incombustible material.

All openings in floors such as for chutes, conveyors, platform elevators, etc., should be protected by automatic fire doors. No openings for shafts or belts should be allowed, as they furnish a ready passage for fire from floor to floor.

All door openings in dividing walls, stair and shaft walls should be provided with automatic fire doors. There are a number of fire doors made for such purpose, namely solid steel doors, tin clad wooden doors, hollow metal doors, corrugated iron doors with asbestos lining and a number of similar patented doors. Solid steel doors are made of steel plates of #12 or #14 U. S. gauge, reinforced with angles. Tin clad wooden doors are made of wood covered with two or three thicknesses of tin. Hollow metal doors consist of cast plates molded to various designs. Corrugated iron doors with asbestos lining are made of two or three thicknesses of asbestos covered with corrugated sheet iron. Of other doors used the rolling steel shutters and the double sliding elevator doors are used to a great extent.

Fire wall openings should be protected with doors on both sides of walls. Doors are either of hinged, sliding or rolling type. The hinged door should have a strong check and holder to automatically close it. The sliding and rolling door if held open, must have a fusible link to automatically close it in case of fire. All sills, lintels and frames of such doors must be of incombustible material.

In order to effectually protect building and contents from fire and to arrest the spread of conflagration, an automatic sprinkler system should be installed. A standard sprinkler system consists of series of pipes suspended from the ceiling and having sprinkler heads with fusible links. The pipes are from eight to eleven feet on centers, depending upon the construction of building and the sprinkler heads are usually proportioned so that one head will serve about one hundred square feet. The fusible link of the sprinkler head will melt and admit a stream of water when the surrounding temperature reaches 160 degrees Fahrenheit. In buildings where the nature of the occupancy is such that very high temperatures are employed, the fusible heads are made to melt at 212 degrees Fahrenheit.

The piping is connected by means of branch risers to a main feeder, which is supplied with water in the following manner:

(1) By gravity tank located above the roof, at least twenty five feet above highest sprinkler head in the building, thus supplying a pressure head.

(2) By steel pressure tank located above the roof where water is kept under air pressure. The air pressure is supplied by means of an air pump.

(3) By means of an electrical or steam driven fire pump which forces water into the sprinkler mains. This pump is connected to the city water supply by large piping and operates either automatically or by manual control.

A standard system should have at least two sources of supply, always having a gravity tank and one of the others.

Where it is found cheaper to pay a somewhat higher insurance rate than to install a standard system, a one source supply system is used. This usually consists of a gravity tank of sufficient elevation.

The above described system is known as a "wet system". It can be used only where the temperature of the building never drops below 42 degrees Fahrenheit. Where lower temperatures are maintained, the so-called "dry system" is used. In the dry system the general piping and water sources are the same as in the wet system, but the distribution branches are filled with air under pressure. When the sprinkler head opens, the air pressure is released, opening a dry valve in the main supply pipe and allowing water to flow through the pipes to the open sprinkler heads.

In either system, an outside connection is provided whereby water may be supplied directly to the system by means of fire apparatus. This is essential where the house supply becomes exhausted during fire.

There are a number of safety devices such as check valves, alarm bells, etc., used in all systems.

FIRE PROTECTION-(continued)

Where automatic sprinklers are not used, other fire fighting apparatus must be employed. Chief among these are standpipes directly connected to city water supply and having reels of fire hose connected on each floor. Chemical extinguishers and buckets filled with sand or water are also very often used.

From data supplied by the various insurance companies and boards of underwriters, it is clearly shown that a mill constructed building equipped with an approved automatic sprinkler system furnishes an excellent fire risk. Such buildings can be classed with fireproof buildings in every respect and furnish as good a protection to the contents as most of the fireproof buildings.

COST.

The cost of the different parts of a building varies with the local conditions, cost of labor and cost of materials,

This subject is a very difficult one to handle, for the reason that costs are always relative, and what may be right in one instance, may be sadly in error in another case which appears to be similar. A correct estimate of the cost of a building is of the utmost importance, as frequently the cost will be the deciding factor in the choice of the kind of building to be erected, and at times will determine whether the building is to be erected at all.

We will also take up the comparative costs of mill constructed buildings and their most important competitive type, the reinforced concrete buildings.

The discussion of the subject of cost will be divided into:

(1) Cost of material.
(2) Cost of labor.
(3) Cost of erection.
(4) Cost of maintenance.

The cost of material varies with the proximity of the building to the source of supply, the cost of transportation and the relation between supply and demand. For this reason no definite cost of material can be given.

To illustrate:

The cost of brick will depend upon whether the kilns are located within team or truck hauling distance from the building, or whether it has to be shipped by railroad. The cost of timber will depend upon whether it is to be taken from the local lumber yards or is to be shipped from the mill. In this case, timber of the same quality and grade will cost more when taken from the local yards. Also larger size timbers will cost more per thousand board feet than smaller size lumber of the same quality. When building operations are extensive and the demand for material is great, the prices will rise. On the other hand, during a period of depression the prices will decline.

The cost of labor is also a very uncertain quantity, depending entirely upon union regulations. The rate of wages paid in the building trades will depend upon the strength of the labor unions and the organization of the various trades.

In a large city like Chicago, the various labor unions are organized into a central Building Trades Council, while the employers are organized into a Contractors' Association. These two bodies fix the scale of wages for the different trades. This rate is constantly varying and has a general upward tendency.

This is illustrated by the comparison of the rates in Chicago during 1915 and 1916 for the same trades:

RATE OF WAGES PER HOUR.

Trade.	1915	1916.
Carpenters................................	$ .65	$ .70
Cement Finishers...........................	.65	.67-1/2
Laborers and Hodcarriers...................	.40	.45
Marble Cutters and Setters.................	.68-3/4	.71-7/8
Ornamental Iron Setters....................	.67-1/2	.70
Sheet Metal Workers........................	.68-3/4	.70
Stone Cutters..............................	.62-1/2	.70
Structural Iron Setters....................	.68	.69

Outside of the cost of labor and material there are a number of items which enter into the cost of the building. These items can be classified under a general heading of erection or overhead cost. This will include superintendence, permits, equipment, office expense, watchman, timekeeper, etc. The erection cost can be easily estimated and will depend entirely upon the size of the job and the organization of the contractor.

In designing a building, the cost of maintenance and depreciation must be considered together with the initial cost of the building. The maintenance charges are made up of the following items:

(1) Insurance.
(2) Taxes.
(3) Heating.

The cost of insurance will depend upon the type of construction, whether building is sprinkled or not, the fire exposure and the nature of the occupancy. The standard mill constructed building, if sprinkled, will command almost as low a rate of insurance as a fireproof building. The location of the building with respect to other buildings or fire hazards and nature of exterior walls and windows on such exposures will influence insurance rates.

Taxes will depend upon the cost of land and building. As the cost of the building will vary with the type of construction, which in turn will regulate the amount of taxes, this must be considered by the engineer.

The cost of heating the building will also be a function of the type. It will cost less to heat a mill building than a concrete building of the same cubical content, all other things being equal. The thick walls and heavy framing of a mill constructed building will transmit less heat than a concrete building. On the other hand, a flat slab concrete building having the same working space will be of a smaller cubical content due to its reduced floor thickness and will consequently require less heat.

Actual figures, based on existing buildings, will alone determine which is the most edonomical.

The question of depreciation has been widely discussed among owners and engineers, with no definite conclusions. It is customary to figure about 2% depreciation per year for a mill building and about 1% for a concrete building. This is approximate at best, as reinforced concrete construction is of recent origin and no definite data as to how long such buildings will stand, can be obtained.

Another charge to be considered in making an estimate for a building - the charge for obsolescence. It is found by observation that a commercial building may outgrow its usefulness before it is actually deteriorated. The changes of condition, such as larger machinery, changed character of surroundings, different requirements for light and ventilation, etc., may necessitate the early abandonment of the building. The exact percentage to be charged for obsolescence is indefinite, and must be based upon the probable industrial changes and the nature of the construction. A concrete building with large spans and a maximum amount of window area will be useful for a much longer period than a mill constructed building with its smaller spaces and large piers.

In order to make a preliminary estimate of cost of a building, before working drawings are made, it is customary to figure the cost per cubic foot of building or per square foot of total floor area. In figuring the cubical content of the building, the area of a typical floor is multiplied by the total height, from the underside of the foundation to the highest point of roof. The total floor area is found by adding the areas of each floor, including basement. Roof is not included. The cost of a standard sprinkled mill constructed building varies from 8-1/2 cents to 12 cents per cubic foot. The cost per square foot will vary from $1.10 to $1.50.

To illustrate the cost of the various trades that enter into the construction of the building, we will give a few examples taken from actual practice.

COST-(continued)

SEVEN STORY AND BASEMENT MILL CONSTRUCTED BUILDING.

BUILT IN CHICAGO IN 1908.

Live Load per square foot - - - 200 lbs.

Total floor area - - 112000 square feet.

Cubical content - - 1500000 cubic feet.

Cost per square foot - - - - - - - -$ 1.30.

Cost per cubic foot - - - - - 9.8 cents.

Character of Work	Cost per Cubic Foot.
Masonry	3.19 cents.
Carpentry	2.15 "
Structural Steel	1.87 "
Fire Doors	1.24 "
Fire Windows and Sheet Metal	0.15 "
Roofing	0.03 "
Plumbing	0.38 "
Glass	0.04 "
Painting	0.10 "
Steam Heating	0.67 "
Elevators	0.35 "
Sprinkler System	0.64. "

COST-(continued)

SEVEN STORY AND BASEMENT MILL CONSTRUCTED BUILDING.

FIGURES TAKEN IN 1915 - CHICAGO.

Live Load per square foot - 280 lbs.

Total Floor Area - - 120000 square ft.

Cubical Content - 1500000 cubic ft.

Cost per square foot - - - - - $ 1.08.

Cost per cubic foot - - - -8.6 cents.

Character of Work	Cost per Square Foot.		Cost per Cubic Foot.	
Masonry	34.3	cents.	2.7	cents.
Carpentry	38.3	"	3.10	"
Structural Steel.&.Iron.	7.7	"	0.6	"
Miscellaneous Iron	4.9	"	0.4	"
Fire Escapes	0.7	"	0.06	"
Fire Windows & Sheet Metal	2.5	"	0.20	"
Roofing	0.4	"	0.03	"
Plumbing	2.0	"	0.20	"
Glass & Glazing	0.3	"	0.02	"
Painting	0.4	"	0.03	"
Heating	5.0	"	0.40	"
Elevators	1.9	"	0.10	"
Sprinkler System	7.5	"	0.6	"
Electric Work	1.4	"	0.10	"
Plastering	0.8	"	0.06	"

COST-(continued)

TWO STORY AND BASEMENT MILL CONSTRUCTED BUILDING.

BUILT IN CHICAGO IN 1917.

Live Load per square foot - - - 100 lbs.

Total floor area - - 37500 square feet.

Cubical content - - 525000 cubic feet.

Cost per square foot - - - - - - - $ 1.63.

Cost per cubic foot - - - - -11.5 cents.

Character of Work	Cost per Cubic Foot.	
Masonry and Carpentry	6.14	cents.
Structural Steel	0.47	"
Sheet Metal and Metal Windows	0.42	"
Iron Doors and Miscellaneous Iron	0.89	"
Roofing	0.01	"
Plumbing and Drainage	0.43	"
Glass and Glazing	0.01	"
Painting	0.01	"
Steam Heating	1.39	"
Elevators	0.34	"
Sprinkler System	1.12	"
Electric Wiring	0.26	"
Lathing and Plastering	0.05	"

COST-(continued)

During the last few years, with the perfection of reinforced concrete building construction, there has been a great deal of discussion as to the comparative costs and merits of these two types. The advocates of each type have prepared tables showing the comparative costs and relative merits of these types, which are herewith given:

TABLE #1.

Prepared by Universal Portland Cement Company.

-:-

COMPARATIVE COSTS OF REINFORCED CONCRETE AND MILL CONSTRUCTED BUILDINGS
(From standpoint of Owner)

BUILDING 100' by 175'
7 stories and basement.

Total Floor Area
140,000 sq. ft.

	REINFORCED CONCRETE (FIREPROOF)	MILL CONSTRUCTION (NOT FIREPROOF)
First Cost of Building	$1.35 per sq. ft. or $189,000.00	$1.20 per sq. ft. or $168,000.00
First Cost Sprinkler System	14,000.00	14,000.00
Total First Investment	$203,000.00	$182,000.00

First Investment Fireproof More Than Mill Construction, $21,000.00.

		REINFORCED CONCRETE (FIREPROOF)	MILL CONSTRUCTION (NOT FIREPROOF)	
Interest on First Investment	6%	$ 12,180.00	$ 10,920.00	6%
Tax on First Investment	1%	2,030.00	1,820.00	1%
Depreciation on Building	0.5%	945.00	3,360.00	2%
Obsolescence	1.0%	1,890.00	3,360.00	2%
Depreciation on Sprinkler	10%	1,400.00	1,400.00	10%
Repairs to Building	1/4%	472.50	1,680.00	1%
Damage to Building by Vermin-None			200.00	Est. low
Auxiliary Fire Equipment-Estimated		200.00	300.00	Est.
Fire Insurance on Building-None Reqd.			235.20	14¢ on $100.
		$ 19,117.50	$ 23,275.20	

Yearly Expense Fireproof Less Than Non Fireproof $ 4,157.70

The yearly saving of $4,157.70 capitalized at 6% represents $69,295.00. Therefore, actual cost of concrete building is $119,705.00 in comparison with one of mill construction costing 168,000.00.

TABLE #1 - (continued)

Prepared by Universal Portland Cement Company.

-:-

COMPARATIVE COSTS OF REINFORCED CONCRETE AND MILL CONSTRUCTED BUILDINGS
(From standpoint of Owner occupying building)

BUILDING 100' by 175' 7 stories and basement	REINFORCED CONCRETE (FIREPROOF)	Total Floor Area 140,000 sq. ft. MILL CONSTRUCTION (NOT FIREPROOF)
First Cost of Building	$1.35 per sq.ft. or $189,000.00	$1.20 per sq.ft. or $168,000.00
First Cost Sprinkler System	14,000.00	14,000.00
	$203,000.00	$182,000.00
Damage to Contents by Vermin	50.00	250.00 Est.
Fire Insurance on Contents. 26¢ on $100. (Valuation $250,000)	650.00	750.00 (30¢ on $100. $250,000 valuation)
	700.00	1,000.00
From Sheet #1.........	$ 19,117.50	$ 23,275.20
	$ 19,817.50	$ 24,275.20

Yearly Expense Fireproof Less Than Mill Construction $ 4,457.70.

Capitalized at 6%, this yearly saving represents $74,295.00 which can be applied as a mortgage which can be renewed indefinitely, if desired, and it generally is desirable to do this because most businesses pay better dividends than 6%. Therefore, the actual cost of concrete building is $114,705 in comparison with one of mill construction costing $168,000.

COST-(continued)

TABLE #2.

Prepared By American Lumberman.

-:-

COMPARATIVE COST OF REINFORCED CONCRETE AND MILL CONSTRUCTED BUILDINGS.

-From standpoint of Owner-

BUILDING 100' by 175' 7 stories and basement	Total Floor Area 140,000 square feet (In concrete, including roof, 157500sq.ft

	REINFORCED CONCRETE	MILL CONSTRUCTION
First Cost of Building	$1.35 per sq.ft or $212,625.00	$1.20 per sq.ft. or $168,000.00
First Cost of Sprinklers (Lindstrom)	13,000.00	12,250.00
Total First Investment	$225,625.00	$180,250.00

First Investment Concrete more than Mill Construction, $45,375.00.

Interest on First Investment	6%	$ 13,537.50	6%	$ 10,815.00
Tax on First Investment	1%	2,256.25	1%	1,802.50
Depreciation of Building	0.5%	1,128.13	2%	3,605.00
Obsolescence	2.5%	5,641.63	1%	1,802.50
Depreciation of Sprinklers	10%	1,300.00	10%	1,225.00
Repairs to Building - practically equal (Hedges)		-		-
Damage to Building by Vermin-none		-	none	-
Auxiliary Fire Equipment-No Difference (Hoxie)		-		-
Fire Insurance on Building Est.		100.00	14¢ per $100.	252.35
Comparative Yearly Cost		$ 23,963.51		$ 19,502.35
Add estimated cost insurance on contents		650.00		750.00
		$ 24,613.51		$ 20,252.35

Difference in annual cost favoring mill construction, $4,361.60, or $72,686.00 capitalized at 6%. Deducting this from first cost of mill constructed building, $180,250.00, leaves $107,564.00 against $225,625.00, first cost of concrete building.

TABLE #3.

COMPARATIVE COST OF REINFORCED CONCRETE AND MILL CONSTRUCTED BUILDINGS.

-From standpoint of Owner-
-Compiled by Paul Gerhardt, Architect, Chicago.-

BUILDING 100' by 150'
7 stories and basement

Total Floor Area
120,000 sqare feet

	REINFORCED CONCRETE (FIREPROOF)	MILL CONSTRUCTION (NOT FIREPROOF)
First Cost of Building	$1.06 per sq.ft. or $127,350.00	$1.02 per sq.ft. or $122,777.00
First Cost Sprinkler System	9,150.00	9,000.00
Total First Investment	$136,500.00	$131,777.00

First Investment Fireproof more than Mill Construction, $4,723.00.

		REINFORCED CONCRETE (FIREPROOF)		MILL CONSTRUCTION (NOT FIREPROOF)
Interest on First Investment	6%	$ 8,190.00	6%	$ 7,906.00
Tax on First Investment	1%	1,365.00	1%	1,317.77
Depreciation of Building	1%	1,365.00	1.8%	2,371.98
Obsolescence	1%	1,365.00	2.2%	2,899.09
Depreciation of Sprinklers	10%	915.00	10%	900.00
Repairs to Building	1/4%	341.25	1%	1,317.17
Damage to Building by Vermin-None		-	Est.	200.00
Auxiliary Fire Equipment- is dependent upon nature of contents of bldg.		-		-
Fire Insurance on Building 5.5¢ per $100.00.		75.07	14¢ per $100.	184.48
		$13,616.32		$17,096.49

Yearly Expense Fireproof Less than Non-Fireproof - $3,480.17.

The yearly saving of $3,480.17 capitalized at 6% represents $58,003.00. Deducting this from first cost of concrete building, $136,500.00, leaves $78,497.00 against $131,777.00, first cost of mill building or about 60%.

TABLE #3 - (continued)

COMPARATIVE COST OF REINFORCED CONCRETE AND MILL CONSTRUCTED BUILDINGS.

(From standpoint of Owner occupying building)

-:-

-Compiled by Paul Gerhardt, Architect, Chicago.-

BUILDING 100' by 150'
7 stories and basement

Total Floor Area
120,000 square feet

	REINFORCED CONCRETE (FIREPROOF)		MILL CONSTRUCTION (NOT FIREPROOF)
First Cost of Building	$1.06 per sq.ft.		$1.02 per sq.ft.
or	$127,350.00		$122,777.00
First Cost Sprinkler System	9,150.00		9,000.00
	$136,500.00		$131,777.00
Damage to Contents by Vermin	50.00.	(Estimated,	250.00
Fire Insurance on Contents 15¢ per $100.(Valuation $250,000)	375.00.	(18¢ per ($100.Val. ($250,000.	450.00
	425.00		700.00
From First Table(Part 1,Table #3)	13,616.32		17,096.49
	$ 14,041.32		$ 17,796.49

Yearly Expense Fireproof Less than Non-Fireproof - $3,755.17.

Capitalized at 6%, this yearly saving represents $62,586.00, which if applied as a mortgage, can be renewed indefinitely, if desired, and it is generally desirable to do this because most businesses pay better dividends than 6%.

Therefore, the actual cost of concrete building is $73,914.00 in comparison with one of mill construction costing $131,777.00.

SUMMARY.

The designer of modern buildings is confronted with a multitude of problems. He must carefully consider the present and possible future needs of those who are to occupy the building, and must produce a structure that will be capable of satisfying these needs.

The type of building to be chosen will a good many times depend upon the cost. There are many classes of business that will not bear the cost of high priced building. In such cases, the designer will be compelled to choose a type of construction which is economical in the first cost, and yet will have a low depreciation factor. Besides the question of initial economy and depreciation he must also consider the cost of maintenance and the requirements for the health, safety and comfort of the occupants. The building must be so designed that it will promote the efficient handling of the occupants' business.

In summing up the principal requirements of a mill constructed building, the following must be considered:

(a) Proper Materials.
(b) Correct Design.
(c) Standardization of Details.
(d) Adaptibility.
(e) Advantages and Disadvantages.

The life of any structure depends mainly upon the use of the proper materials in a correct manner. What are the proper materials for a specific case, is at times difficult to determine. Materials which have given good service under one set of conditions, may prove entirely unsatisfactory in other cases. A slight change in the materials will often give different results even when used under similar conditions.

In a mill constructed building, special care must be taken to see that the proper grade of lumber is used. Timber is more or less of an unknown quantity, due to the many varieties of structural grades on the market. It is difficult to obtain suitable material, unless the specifications are carefully drawn and rigidly adhered to. Even with the utmost care, it is next to impossible to detect whether timber is infected with dry-rot, unless a laboratory analysis is made.

Masonry, steel, sheet metal, roofing, various mechanical equipments, etc., are all important, but their quality has been standardized and with reasonable supervision, there should be no trouble in obtaining good results with them.

When due precautions are taken to obtain the proper materials, satisfactory results may be looked for, both in the initial cost, maintenance and depreciation.

A correctly designed building must be of ample size to accomodate the needs of the occupant and must give absolute protection to the contents. The requirements for safety and comfort of the occupants must be met. This will include provisions for ample light, heat regulations and necessary ventilation. These items naturally vary with different occupancy, and consequantly, each building will be a problem in itself.

The building must be provided with suitable means for fire extinction, such as a sprinkler system, standpipes, chemical extinguishers, etc. An economically designed building must have all details entering into its construction standardized.

This means that the building must be so designed that only standard commercial sizes and shapes are used. Wherever possible, the floor panels should be of equal size, and floors of same height. This will allow the use of the same length of posts, joists, girders, flooring, etc. Standard sizes will allow the repitition of connections, such as post bases, caps, bearing plates, hangers, bolts, anchors, etc. All this tends to reduce the cost of the building and promote ease and speed of erection. It is cheaper to cut, ship and frame timber of equal length and size, and it will take less time to handle during erection. Where castings are used, they should be as far as possible, of the same kind, in order not to have too many patterns. This will also apply to the fabricated steel connections and in general to all details.

This standardization of details should not be limited to the framing, but should be applied to all other features of the building. Doors and windows should be of the same size wherever possible, and should always be of standard dimensions. Even the architectural treatment of the building should be proportioned with this point in view.

Mill constructed buildings are adapted to a variety of uses. In almost any industry where conditions are normal and no extraordinary fire hazards prevail, a mill constructed building may be used to advantage. It will carry comparatively heavy loads, say up to 300 pounds per square foot, without making the structure too cumbersome and expensive. Such buildings have been used with entirely satisfactory results for a great number of purposes and under various conditions. Factories, warehouses, shops, mercantile buildings, office buildings, cold storage plants, freight houses, mills, and buildings of similar nature have been built of this type and have given good service in most instances.

There have been a number of failures of this type of construction, but upon careful analysis of the underlying causes, they proved to be due to faulty materials or methods used during construction, or to improper usage of building.Material employed was either of poor quality, not adapted for that particular use, or was put into building without consideration for its proper protection.

A timber beam or post, strong enough to carry the desired load, if placed in the building in a green condition without proper means of drying out, will within a short time, rot away and may cause failure of the building: or the structural members themselves, although strong enough, may cause failure of the building due to weak connections. However, failures have occurred in other types of buildings, where details were not given sufficient attention.

Failures have occurred in buildings due to conditions entirely independent of the construction. A well designed building, if overloaded, may fail, either entirely or in part.

When partial failure occurs, it is much easier to repair a mill constructed building, than one of concrete. This also holds true where changed occupancy requires alterations in the building.

Reinforced concrete buildings are more fireproof than mill constructed buildings, but the slightly reduced fire protection qualities of a well built sprinkled mill building, is more than justified when the comparative costs of the two types are considered. The insurance rates on the contents of such buildings are almost identical. The rate on the building itself is higher for the mill building than for the concrete, but this rate is so small in either case, that it will not materially alter the maintenance charges.

Another important item to be considered in this connection, is the question of demolishing the building. In our rapidly growing cities, with their constant change of the character of the industrial neighborhoods, it may become necessary to remove buildings in order to make room for other improvements. In such contingency, it is much easier and cheaper to remove a mill building than a reinforced concrete structure. Furthermore, in demolishing a mill building, there is a certain amount of salvage, as the framing and brick can be used again, while a concrete building is a total loss.

A great deal has been written on the question of cost of different types of buildings. Tables and charts have been prepared, giving figures based either on actual cost or upon estimates. These tables should not be used in estimating the cost of a building, unless allowances are made for changed conditions, such as cost of materials and labor. As a guide for the comparison of the cost of different types, these tables serve a useful purpose. The conclusions drawn in these tables are vastly different, depending upon the buildings selected for comparison. It is only natural that the advocates of certain materials will select cases which favor their type of construction.

SUMMARY-(continued)

We have endeavored in this paper to describe the mill constructed type of buildings and its application to modern industrial conditions. Mill construction, while it does not rank as the very best type obtainable, under certain conditions is the only type to be used. It has its definite place in the building industry and if proper consideration is given to the changing conditions, it will not be readily displaced by any other type.

CONTENTS OF STORAGE WAREHOUSES.

MATERIAL.	Weights per Cubic Foot of Space. Pounds.	Height of Pile. Feet.	Weights per Square Foot of Floor. Pounds.	Recommended Live Loads, Pounds per Square Foot.
GROCERIES, WINES, LIQUORS, ETC.				
Beans, in bags	40	8	320	250 to 300
Canned Goods, in cases	58	6	348	
Coffee, Roasted, in bags	33	8	264	
Coffee, Green, in bags	39	8	312	
Dates, in cases	55	6	330	
Figs, in cases	74	5	370	
Flour, in barrels	40	5	200	
Mollasses, in barrels	48	5	240	
Rice, in bags	58	6	348	
Sal Soda, in barrels	46	5	230	
Salt, in bags	70	5	350	
Soap Powder, in cases	38	8	304	
Starch, in barrels	25	6	150	
Sugar, in cases	51	6	306	
Sugar, in barrels	43	5	215	
Tea, in chests	25	8	200	
Wines and Liquors, in barrels	38	6	228	
DRY GOODS, COTTON, WOOL, ETC.				
Burlap, in bales	43	6	258	200 to 250
Coir Yarn, in bales	33	8	264	
Cotton, in bales, compressed	18	8	144	
Cotton Bleached Goods, in cases	28	8	224	
Cotton Flannel, in cases	12	8	96	
Cotton Sheeting, in cases	23	8	184	
Cotton Yarn, in cases	25	8	200	
Excelsior, compressed	19	8	152	
Hemp, Italian, compressed	22	8	176	
Hemp, Manila, compressed	30	8	240	
Jute, compressed	41	8	328	
Linen Damask, in cases	50	5	250	
Linen Goods, in cases	30	8	240	
Linen Towels, in cases	40	6	240	
Sisal, compressed	21	8	168	
Tow, compressed	29	8	232	
Wool in bales, compressed	48			
Wool in bales, not compressed	13	8	104	
Wool, Worsteds, in cases	27	8	216	

CONTENTS OF STORAGE WAREHOUSES.

MATERIAL.	Weights per Cubic Foot of Space. Ppunds.	Height of Pile. Feet.	Weights per Square Foot of Floor. Pounds.	Recommended Live Loads, Pounds per Square Foot.
BUILDING MATERIALS-				
Cement, Natural	59	6	354	300 to 400
Cement, Portland	73	6	438	
Lime and Plaster	53	5	265	
HARDWARE, ETC.				300 to 400
Door Checks	45			
Hinges	54			
Locks, in cases packed	31			
Sash Fasteners	48			
Screws	101			
Sheet Tin, in boxes	278	2	556	
Wire Cables, on reels			425	
Wire, Insulated Copper, in coils	63	5	315	
Wire, Galvanized Iron, in coils	74	4-1/2	333	
Wire, Magnet, on spools	75	6	450	
DRUGS, PAINTS, OILS, ETC.				
Alum, Pearl, in barrels	33	6	198	200 to 300
Bleaching Powder, in hogsheads	31	3-1/2	102	
Blue Vitriol, in barrels	45	5	226	
Glycerine, in cases	52	6	312	
Linseed Oil, in iron drums	45	4	180	
Linseed Oil, in barrels	36	6	216	
Logwood Extract, in boxes	70	5	350	
Rosin, in barrels	48	6	288	
Shellac, Gum	38	6	228	
Soda Ash, in Hogsheads	62	2-3/4	167	
Soda, Caustic, in iron drums	88	3-1/3	294	
Soda, Silicate, in barrels	53	6	318	
Sulphuric Acid	60	1-2/3	100	
White Lead Paste, in cans	174	3-1/2	610	
White Lead, dry	86	4-3/4	408	
Red Lead and Litharge, dry	132	3-3/4	495	
MISCELLANEOUS.				
Glass in Chinaware, in crates	40	8	320	300
Hides and Leather, in bales	20	8	160	
Hides, Buffalo, in bundles	37	8	296	
Paper, Newspaper & Strawboards	35	6	210	
Paper, Writing and Calendered	60	6	360	
Rope, in coils	32	6	192	

PART

TWO.

PART TWO.

This part of our Thesis consists of the structural design of a six story and basement mill constructed building, occupying a ground area of 160 x 108 feet, to be used for warehouse purposes, with a loading of 250 lbs. per square foot on first two floors and 200 lbs. per square foot on the remaining floors.

The building is to be used for furniture warehouse purposes, wherein the stoves and ranges will be stored in the basement, the rugs and linoleums on the first floor, the brass goods on the second floor, and other furniture on the remaining floors.

The various story heights (floor to floor) will be:

Basement	10 feet.
1st floor	14 feet.
2nd floor) 3rd floor) 4th floor) 5th floor) 6th floor)	12 feet.

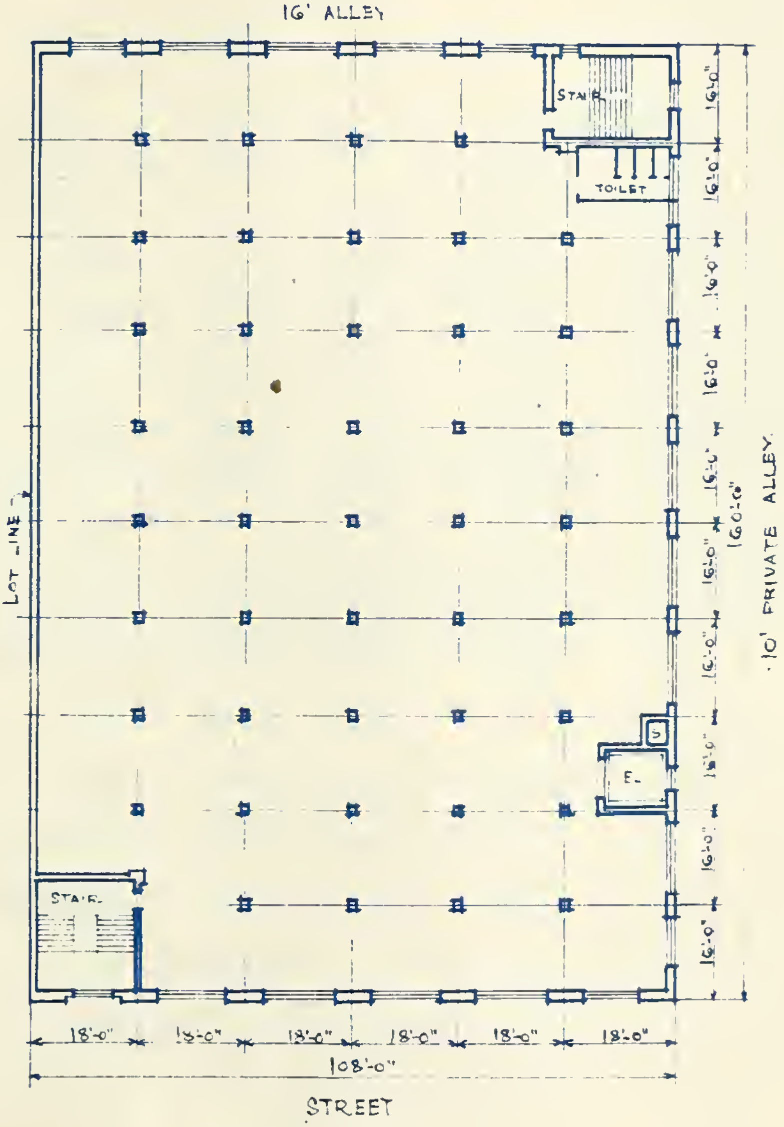
SPECIFICATIONS:

Complete specifications for strustural parts of the building, viz: foundations, walls, lumber, etc.

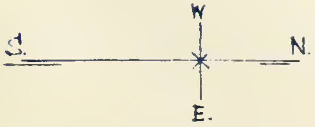
The Chicago Building Ordinance will be followed in the design of the building.

LAYOUT OF BUILDING:

For layout of building, see Figure No. 1.



· BUILDING LAYOUT ·



· FIGURE NO. 1 ·

NOTES - GENERAL:

The typical panels of a mill building should always be of even feet so as to enable the use of commercial sizes of timber, which comes in even foot lengths.

Girders should run perpendicular to the wall admitting the maximum amount of light to the building. This is done in order not to obstruct the light rays entering building, thus allowing the top of windows to be immediately below the ceiling and still obtaining the full benefit of the upper portion of the window. This is very important in manufacturing and office buildings where a maximum of light is wanted.

In our case, the street wall is the maximum light wall and girders will run perpendicular to it.

DESIGN:

(1) The design of building is commenced at the roof and gradually worked downward toward foundations.

(2) Lumber used will be Long Leaf Yellow Pine throughout, allowing 1300 lbs. per square inch as working stress in tension with grain, and 1100 lbs. per square inch for compression with grain, as per Chicago Building Ordinance:

"ALLOWABLE STRESSES AND SPECIAL REQUIREMENTS FOR TIMBER.) The maximum allowable stresses in pounds per square inch on actual sections for timber shall be as follows:

	Extreme fibre stress and tension with grain.	Compression with grain.	Compression across grain in buildings hereafter erected.	Compression across grain in existing buildings.	Shear with grain.
Douglas Fir and Long Leaf Yellow Pine................	1,300	1,100	250	400	130
Oak...........................	1,200	900	500	600	200
Short Leaf Yellow Pine..........	1,000	800	250	300	120
Norway Pine......................	800	700	200	300	80
White Pine.......................	800	700	200	300	80
Hemlock..........................	600	500	150	300	60

The unit stress on timber posts shall comply with the formula

$$C(1=\frac{L}{80D})$$

In which formula:

C equals compressive strength of timber with the grain as given in the table.
L equals length in inches.
D equals least diameter inches.

The maximum length of a timber post shall not exceed thirty diameters.

Timber columns shall not be used in buildings of greater height than twice the width of the building nor in buildings over one hundred feet in height.

QUALITY OF TIMBER.) Timber used for building purposes shall be sound, well manufactured, close grained, free from wind shakes or from dead, loose, decayed, encased or pitch knots, or knots and other defects than will materially impair its strength and durability."

DESIGN (continued)

(3) The least sizes of timbers and planks used will be as given in the following table:

Posts...............10" x 10" or 100 square inches.

Beams...............6" x 12" or 72 square inches.

Roofs...............2-5/8" in thickness.

Floors...............3-1/2" in thickness of two layers, 2-5/8" and 7/8".

The above sizes are recommended by the insurance companies and building laws of various cities, as furnishing a section of sufficient size to prevent the collapse of building due to burning out of bearing members, before fire fighting apparatus comes into action.

(4) In designing, the commercial sizes of timber must be reduced by 1/2" for beams and 3/8" for planks, i.e., 6" x 12" must be figured as 5-1/2" x 11-1/2", and 3" plank must be figured as 2-5/8", to allow for dressing.

DESIGN OF ROOF:

Panel 16 feet x 18 feet = 288 square feet.

LOAD:

Tar and Gravel Roofing = 10 lbs. per square foot.
Boards = 3 " " " "
Joists = 4 " " " "
Wind and Snow = 25 " " " "
Total on Joists = 42 " " " "

Say 45 lbs. per square foot.

DESIGN OF ROOF (continued)

JOISTS:

Assume 6" x 12" joists. Span = 18'-0".

Safe Load = $\frac{bd^2f}{9L}$ (See page 451). Net Span = 17'-6".

$$= \frac{5.5 \times 11.5 \times 11.5 \times 1300}{9 \times 17.5} = 6000 \text{ lbs.}$$

Spacing of joists = $\frac{6000}{45 \times 17.5}$ = 7.6 feet.

Therefore joists will be spaced at 7'-0" centers, provided roof boards will span this safely.

ROOF BOARDS:

3" boards will be used.

Load on roof boards = 40 lbs. per square foot.

Maximum span for roof boards:

$$M = \frac{1}{8}WL^2 \times 12 = \frac{SI}{C}$$

$$= 1300 \times \frac{1}{6} \times 12 \times 2\frac{5}{8} \times 2\frac{5}{8},$$

$L = 17.4.$

Therefore spacing of joists governs - Joists spaced 7'-0" centers.

GIRDERS.

Load on joist = 45 lbs. per square foot (Actual).

Wt. of girder = 5 " " " " (Approx.)

Total Load = 50 " " " "

Total Span = 16'-0".

Net Span is equal to the clear span between post caps plus half the width of post caps, which in this case is 15'-4".

Total load per panel = 50# x 18 x 16 = 14,400#.

DESIGN OF ROOF (continued)

GIRDERS (continued)

$$\frac{bd^2f}{9L} = 14{,}400 \text{ lbs.}$$

$$bd^2 = \frac{14{,}400 \times 9 \times L}{f} = \frac{14{,}400 \times 9 \times 15.33}{1300} = 1530.$$

Use 12" x 12" Girder.

The above is the customary method of figuring the load as uniformly distributed over girder. This is a safe method of figuring, as can readily be seen by checking up for concentrated joist loading.

DESIGN OF FLOORS:

3rd, 4th, 5th and 6th FLOORS.

LOAD:

Live Load = 200 lbs. per square foot.

Dead Load
Flooring = 10 lbs. per square foot.
Joists = 10 " " "
Girders = 5 " " "

Total Load = 225 lbs. per square foot.

FLOORING:

In figuring flooring, the wearing courses of 7/8" maple is not figured to take any load.

$$\text{Safe Load} = \frac{12 \text{ x } 2\text{-}5/8 \text{ x } 2\text{-}5/8 \text{ x } 1300}{9 \text{ x } L} = 210\# \text{ x } L.$$

$$L = 7'\text{-}6".$$

JOISTS:

Span = 18'-0". Net Span = 17'-0".

Load = 220 lbs. per square foot.

Assume 6" x 16" Joists.

$$\text{Safe Load} = \frac{bd^2f}{9L} = \frac{5.5 \text{ x } 15.5^2 \text{x } 1300}{9 \text{ x } 17} = 11{,}240 \text{ lbs.}$$

$$\text{Spacing} = \frac{11240}{220 \text{ x } 17} = 3.0 \text{ feet.}$$

Assume 8" x 14" Joists.

$$\text{Safe Load} = \frac{bd^2f}{9L} = \frac{7.5 \text{ x } 13.5 \text{ x } 13.5 \text{ x } 1300}{9 \text{ x } 17} = 11{,}600\#$$

$$\text{Spacing} = \frac{11600}{220 \text{ x } 17} = 3.10 \text{ feet.}$$

6" x 16" or 8" x 14" joists can be used, but since 8" x 14" joists will increase the headroom by two inches, and can be spaced one inch further apart, we will use 8" x 14" joists - 3'-0" centers.

DESIGN OF FLOORS: (continued)

GIRDERS:

Total Span = 16'-0". Net Span = 14'-8".
(16'-0"-10"for column -6" for $\frac{1}{2}$ cap.)

LOAD:

Dead Load = 25 lbs. (See sheet #113)

Live Load = 170 lbs.= 85% of full live load as allowed by City Ordinance.

Total Load =195 lbs.

Total Load per panel = 195# x 18 x 16 = 56,100#.

$$bd^2 = \frac{56100 \times 9 \times 14.66}{1300} = 5690.$$

Assume two 10" x 18". $bd^2 = 2 \times 9.5 \times 17.5 \times 17.5 = 5818.$

Use two 10" x 18" beams bolted together with 3/4" bolts and having 7/8" Maple strips as separators. The reason two 10" beams are used instead of a single timber 20" wide, is because it is very difficult and far more expensive to get the large size beam and also harder to handle in the field.

1st and 2nd FLOORS:

LOAD:

Live Load = 250 lbs. per square foot.

Dead Load:
Flooring = 10 " " " "
Joists = 12 " " " "
Girders = 6 " " " "
Total Load = 278 " " " "

FLOORING:

$$\text{Safe Load} = \frac{12 \times 2\text{-}5/8 \times 2\text{-}5/8 \times 1300}{9 \times L} = 260\ L.$$

L = 6'-9" = Maximum span of 3" board.

DESIGN OF FLOORS: (continued)

1st and 2nd FLOORS (continued)

JOISTS:

Assume spacing of 3'-0". Span = 17'-0".

Load on Joist = 3 x 17 x 272 = 13,880 lbs.

$$13,880 = \frac{bd^2 \times 1300}{9 \times 17}$$

$$bd^2 = 1635.$$

Assume 8" joist. $d^2 = \frac{1635}{7.5} = 218.$ d = 14.75.

Use 8" x 16" Joists.

Maximum spacing of 8" x 16" joists,

$$= \frac{7.5 \times 15.5 \times 15.5 \times 1300}{9 \times 17 \times 17 \times 272} = 3.3 \text{ feet.}$$

8" x 16" joists at 3'-3" centers can be used.

ALTERNATE DESIGN:

Since 8" x 16" Joists spaced 3'-3" centers, reduce the headroom of floors, or will require extra wall height, it will be better to use laminated floors. This will also improve the appearance of the ceilings.

LAMINATIONS:

Assume 8" Lamination either 2" or 3" wide, laid over girders and spiked together to form a slab. Laminated flooring will be designed as a beam 12" wide and 8" deep.

LOAD:

Live Load = 250 lbs. per square foot.

Dead Load = 25 " " " "

Total Load = 275 lbs. per square foot.

Net Span = 17'-0".

Load per foot = 275 x 17 = 4675 lbs.

DESIGN OF FLOORS: (continued)

1st and 2nd FLOORS (continued)

LAMINATIONS

Safe Load for 8" Lamination $= \frac{12 \times 7.5 \times 7.5 \times 1300}{9 \times 17} = 5740\#.$

" " " 6" " $= \frac{12 \times 5.5 \times 5.5 \times 1300}{9 \times 17} = 3080\#.$

Therefore 8" Laminations will be used.

GIRDERS:

Dead Load = 30 lbs. per square foot, (Lamination and Girder)

Live Load=85% x 250 = 212 lbs. per square foot.

Total Load = 242 lbs. per square foot.

Span = 16'-0". Net Span = 14'-8" (See page ///).

Total Load per panel = 18 x 16 x 242 = 69,700 lbs.

$$bd^2 = \frac{69700 \times 9 \times 14.66}{1300} = 7,090.$$

Assume two 12" x 18".

$$bd^2 = 2 \times 11.5 \times 17.5 \times 17.5 = 7,040.$$

$$\text{Safe Load} = \frac{bd^2f}{9L} = \frac{7040 \times 1300}{9 \times 14.66} = 69,400.$$

Therefore since load carried is but slightly heavier than the safe load figured we will use the above beams - two 12" x 18" Long Leaf Yellow Pine.

DESIGN OF GIRDER OVER DRIVEWAY:

Span = 32'-0".

Load per foot = 27600 - (1560 + 2940 + 3100)

= 20000 lbs.

$$M = \frac{1}{8}wL^2 = \frac{1}{8} \times 20000 \times 32 \times 32 \times 12 = 30,720,000.$$

$$\frac{I}{C} = \frac{M}{16000} = \frac{30720000}{16000} = 1920$$

Reaction = 20000 x 16 = 320,000 lbs.

From Carnegie Hand Book -

Use Box Girders

$$2 \left(\begin{array}{ll} \text{Web} & 42" \times 7/16". \\ \text{Flange Angles} & 6"\times6"\times1/2". \\ \text{Flange Plates} & 14" \times 3/4". \end{array} \right) \quad \frac{I}{C} = 1946.$$

For Column use

4 Angles 6"x4"x5/8".

1 Web 12" x 1/2".

· COLUMN DESIGN ·

AREA OF FLOOR LOAD
SUPPORTED = 18'-0" x 16'-0" = 288 SQ.FT.

NATURE OF LOAD	PROPORTION OF LOAD	PANEL LOADS		COLUMN SECTION.	FLOOR HEIGHTS ROOF
D.L. 25# L.L. 25# ROOF	FULL D.L. " L.L.	25 x 288 25 x 288	7200 7200	10" x 10" L.L.Y.P. MINIMUM ALLOWED BY CITY ORDINANCE	6TH FLOOR. 12'-0"
D.L. 25# L.L. 200# 6TH FLOOR	FULL D.L. 85% L.L.	25 x 288 170 x 288	14400 7200 49000	10" x 10" L.L.Y.P.	5TH FLOOR. 12'-0"
D.L. 25# L.L. 200# 5TH FLOOR	FULL D.L. 80% L.L.	25 x 288 160 x 288	70600 7200 46100	12" x 12" L.L.Y.P.	4TH FLOOR. 12'-0"
D.L. 25# L.L. 200# 4TH FLOOR	FULL D.L. 75% L.L.	25 x 288 150 x 288	123900 7200 43200	14" x 14" L.L.Y.P.	3RD FLOOR. 12'-0"
D.L. 25# L.L. 200# 3RD FLOOR	FULL D.L. 70% L.L.	25 x 288 140 x 288	174300 7200 40300	16" x 16" L.L.Y.P.	2ND FLOOR. 12'-0"
D.L. 30# L.L. 250# 2ND FLOOR	FULL D.L. 65% L.L.	30 x 288 162.5 x 288	221800 8640 46800	18" x 18" L.L.Y.P.	1ST FLOOR 14'-0"
D.L. 30# L.L. 250# 1ST FLOOR	FULL D.L. 60% L.L.	30 x 288 150 x 288	277240 8640 43200 329080	18" x 20" L.L.Y.P.	BASEMENT 10'-0"

THE ABOVE COLUMN SECTIONS WERE OBTAINED FROM SOUTHERN PINE MANUAL. TO CHECK WE WILL DESIGN THE COLUMNS FOR THE THIRD FLOOR AND THE BASEMENT.

HIRD FLOOR COLUMNS —

ASSUME - 14" x 14" COLUMN.

WINSLOW FORMULA - $\$ = C\left(1 - \frac{L}{80 \cdot D}\right) A$

C = 1100 # D = 13.5"

L = 126" A = 182.25 SQ.IN.

$$\$ = 1100 \times \left(1 - \frac{126''}{80 \times 13.5}\right) \times 182.25 = 177000 \#$$

ASEMENT COLUMNS.

· A = 341.25 · · ASSUME 18" x 20" COLUMN ·

$$\$ = C\left(1 - \frac{L}{80 D}\right) A = 1100\left(1 - \frac{100}{80 \times 17.5}\right) 341.25 = 348{,}075 \#$$

CHICAGO BUILDING ORDINANCE REQUIREMENTS for the design of walls, piers and columns.

'WALLS, PIERS AND COLUMNS - DEAD AND LIVE LOADS.)

(a) The full live loads on roofs of all buildings shall be taken on walls, piers and columns.

(b) The walls, piers and columns of all buildings shall be designed to carry the full dead loads and not less than the proportion of the live load given in the following table:

Floor....	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
17.....	85 per cent.																
16.....	80	85															
15.....	75	80	85														
14.....	70	75	80	85													
13.....	65	70	75	80	85												
12.....	60	65	70	75	80	85											
11.....	55	60	65	70	75	80	85										
10.....	50	55	60	65	70	75	80	85									
9.....	50	50	55	60	65	70	75	80	85								
8.....	50	50	50	55	60	65	70	75	80	85							
7.....	50	50	50	50	55	60	65	70	75	80	85						
6.....	50	50	50	50	50	55	60	65	70	75	80	85					
5.....	50	50	50	50	50	50	55	60	65	70	75	80	85				
4.....	50	50	50	50	50	50	50	55	60	65	70	75	80	85			
3.....	50	50	50	50	50	50	50	50	55	60	65	70	75	80	85		
2.....	50	50	50	50	50	50	50	50	50	55	60	65	70	75	80	85	
1.....	50	50	50	50	50	50	50	50	50	50	55	60	65	70	75	80	85

(c) The proportion of the live load on walls, piers and columns on buildings more than seventeen stories in height shall be taken in same ratio as the above table.

(d) The entire dead load and the percentage of live load on basement columns, piers and walls shall be taken in determining the stress in foundations."

'THICKNESS OF WALLS AND COLUMNS-CONSTRUCTION-WIDTH-HEIGHT.)

(a) Brick, stone and solid concrete walls, except as otherwise provided, shall be of the thickness in inches indicated in the following table:

	Basement.	Stories 1	2	3	4	5	6	7	8	9	10	11	12
One-story........	12	12											
Two-story........	16	12	12										
Three-story......	16	16	12	12									
Four-story.......	20	20	16	16	12								
Five-story.......	24	20	20	16	16	16							
Six-story........	24	20	20	20	16	16	16						

(Table continued on next page.)

CHICAGO BUILDING ORDINANCE REQUIREMENTS (continued)

	Basement	Stories											
		1	2	3	4	5	6	7	8	9	10	11	12
Seven-story	24	20	20	20	20	16	16	16					
Eight-story	24	24	24	20	20	20	16	16	16				
Nine-story	28	24	24	24	20	20	20	16	16	16			
Ten-story	28	28	28	24	24	24	20	20	20	16	16		
Eleven-story	28	28	28	24	24	24	20	20	20	16	16	16	
Twelve-story	32	28	28	28	24	24	24	20	20	20	16	16	16

-:- -:- -:- -:-

WALLS:

Of the two methods of wall design, namely that of piers and curtain walls, and straight bearing walls, the former will be used as it is found by experience to be the cheaper of the two. (See PART I, Page 50).

For straight bearing walls, "CHICAGO CITY ORDINANCE" thicknesses govern, which are as follows:

Basement........2'-1")
1st Floor.......1'-9")
2nd " ....1'-9")
3rd " ....1'-9")
4th " ....1'-5")
5th " ....1'-5")
6th " ....1'-5")

These wall thicknesses will be used for north and south walls of our building.

DESIGN OF PIERS: East and West Walls.

For layout of building see Drawing No 1.

NOTE: Ordinance allows us to use common brick, laid up with portland cement mortar with a bearing of 175 lbs. per square inch, or the same brick laid up with cement tempered lime mortar at 125 lbs. per square inch. We will give two designs illustrating both methods, and select the best design for our use.

· PIER DESIGN #1 ·

OMMON BRICK LAID UP IN CEMENT MORTAR

AREA OF FLOOR LOAD
SUPPORTED = 18 x 8 = 144 SQ.FT.

NATURE OF LOAD	PROPORTION OF LOAD	· PANEL LOADS ·		NO. OF SQ. IN. REQ'D.	PIER SECTION	FLOOR HEIGHTS. ROOF
D.L. 25# L.L. 25# WALL PIER ROOF	FULL D.L. " L.L. WALL PIER	25X144 25X144 130X4.5X13 210X15X5	3600 3600 7600 15750	175	5'0" x 1'9" = 1260 SQ.IN.	6TH FLOOR 12'0"
D.L. 25# L.L. 200# WALL PIER 6TH FLOOR	FULL D.L. 85% L.L. WALL PIER	25X144 170X144 130X4.5X13 210X12X5	30550 3600 24500 7600 12600	450	5'0" x 1'9" = 1260 SQ.IN.	5TH FLOOR 12'0"
D.L. 25# L.L. 200# WALL PIER 5TH FLOOR	FULL D.L. 80% L.L. WALL PIER	25X144 160X144 130X4.5X13 210X12X5	78850 3600 23050 7600 12600	715	5'0" x 1'9" = 1260 SQ.IN.	4TH FLOOR 12'0"
D.L. 25# L.L. 200# WALL PIER 4TH FLOOR	FULL D.L. 75% L.L. WALL PIER.	25X144 150X144 130X4.5X13 290X12X5	125700 3600 21600 7600 17400	1000	5'0" x 2'5" = 1740 SQ.IN.	3RD FLOOR 12'0"
D.L. 25# L.L. 200# WALL PIER 3RD FLOOR	FULL D.L. 70% L.L. WALL PIER	25X144 140X144 130X4.5X13 290X12X5	175900 3600 20160 7600 17400	1280	5'0" x 2'5" = 1740 SQ.IN.	2ND FLOOR 12'0"
D.L. 30# L.L. 250# WALL PIER 2ND FLOOR	FULL D.L. 65% L.L. WALL. PIER.	30X144 162.5X144 130X4.5X13 290X14X5	224660 4320 23400 7600 20300	1610	5'0" x 2'5" = 1740 SQ.IN.	1ST FLOOR 14'0"
D.L. 30# L.L. 250# WALL PIER 1ST FLOOR	FULL D.L. 60% L.L. WALL PIER	30X144 150X144 ON FOUNDATION 410X10X5	280280 4320 21600 20500 326700	820	5'0" x 2'9" = 1980 SQ.IN.	BASEMENT 10'0"

NOTE:-

THICKNESS OF PIER IS GOVERNED NOT ONLY BY REQUIREMENTS FOR STRENGTH BUT ALSO BY CITY ORDINANCE. BASEMENT PIER IS OF CONCRETE WITH AN ALLOWED PRESSURE OF 400# PER SQ. INCH.

· PIER DESIGN #2 ·

OMMON BRICK LAID UP IN LIME MORTAR.

AREA OF FLOOR LOAD
SUPPORTED = 18 x 8 = 144 SQ. FT.

NATURE OF LOAD	PROPORTION OF LOAD	· PANEL LOADS ·		NO. OF SQ. IN. REQ'D.	PIER SECTION	FLOOR HEIGHTS. ROOF
D.L. 25# L.L. 25# WALL PIER ROOF	FULL D.L. " L.L. WALL. PIER	25 x 144 25 x 144 130 x 4.5 x 12 210 x 15 x 6	3600 3600 7020 18900	265	6'-0" x 1'-9" = 1512 SQ. IN.	12'-0" 6TH FLOOR
D.L. 25# L.L. 200# WALL PIER 6TH FLOOR	FULL D.L. 85% L.L. WALL PIER	25 x 144 170 x 144 130 x 4.5 x 12 210 x 12 x 6	33120 3600 24500 7020 15120	666	6'-0" x 1'-9" = 1512 SQ. IN.	12'-0" 5TH FLOOR
D.L. 25# L.L. 200# WALL PIER 5TH FLOOR	FULL D.L. 80% L.L. WALL PIER	25 x 144 160 x 144 130 x 4.5 x 12 210 x 12 x 6	83360 3600 23040 7020 15120	1060	6'-0" x 1'-9" = 1512 SQ. IN.	12'-0" 4TH FLOOR
D.L. 25# L.L. 200# WALL PIER 4TH FLOOR	FULL D.L. 75% L.L. WALL PIER.	25 x 144 150 x 144 130 x 4.5 x 12 290 x 12 x 6	132140 3600 21600 7020 20880	1480	6'-0" x 2'-5" = 2088 SQ. IN.	12'-0" 3RD FLOOR
D.L. 25# L.L. 200# WALL PIER 3RD FLOOR	FULL D.L. 70% L.L. WALL PIER	25 x 144 140 x 144 130 x 4.5 x 12 290 x 12 x 6	185240 3600 20200 7020 20880	1895	6'-0" x 2'-5" = 2088 SQ. IN.	12'-0" 2ND FLOOR
D.L. 30# L.L. 250# WALL PIER 2ND FLOOR	FULL D.L. 65% L.L. WALL. PIER	30 x 144 162.5 x 144 130 x 4.5 x 12 330 x 14 x 6	236940 4320 23400 7020 27720	2390	6'-0" x 2'-9" = 2376 SQ. IN.	14'-0" 1ST FLOOR
D.L. 30# L.L. 250# WALL PIER 1ST FLOOR	FULL D.L. 60% L.L. WALL PIER	30 x 144 150 x 144 410 x 10 x 6	299400 4320 21600 24600 349,920	875	6'-0" x 2'-9" = 2376 SQ. FT.	10'-0" BASEMENT

NOTE:-

SINCE CEMENT TEMPERED LIME MORTAR IS CHEAPER THAN CEMENT MORTAR AND SINCE FOR GOOD DESIGN IT IS PREFERABLE TO USE A LARGER PIER FOR STABILITY. WE WILL USE THIS DESIGN.

WINDOWS:

Use windows 12'-0" wide by 7'-6" high for 6th. 5th, 4th and 3rd Floors. For Second Floor use window 8'-6" high and for First Floor, 10'-0" high.

DESIGN OF STAIRS:

TOTAL WIDTH REQUIRED:

Net area of building equals 16,000 square feet (about).

Number of stairways required for this type of building is three stairways and two 24" fire escapes. However, by increasing one of the fire escapes to 3'-0" and building it in accordance with all other requirements for such stairway fire escapes, we are allowed to omit one of the interior stairways and figure such stairway fire escape as equivalent to interior stairway and fire escape. However, combined width of interior and exterior stairways must equal that required by ordinance.

$$\text{WIDTH REQUIRED} = 72 \text{ inches plus } \frac{(\text{Area} - 3000)8}{1000}$$

$$= 72 + \frac{13000 \times 8}{1000} = 176 \text{ inches.}$$

Deduct width of stairway fire escape 36 "

Width required for interior stairways 140 inches.

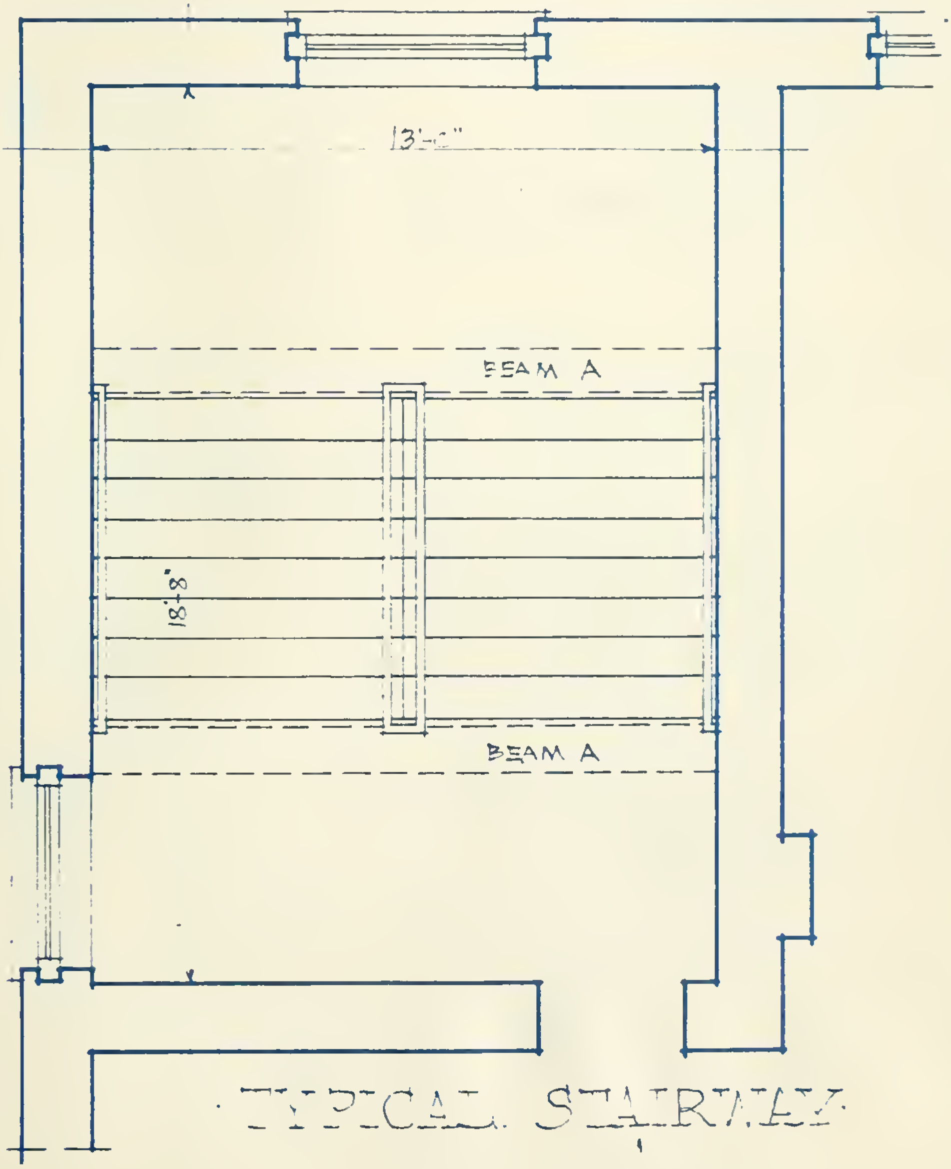
Will use two 6'-0" stairways inclosed in brick walls, having all openings protected by automatic fire doors as required by ordinance.

Use 8" Risers - - - 10" Treads.

DESIGN BEAM "A"

Load = 9'-4" x 125 x 13 = 15,160 lbs. Use 12"x12" Beam.

For layout of stairway see Figure No. 2.



TYPICAL STAIRWAY

FIGURE NO. 2.

TANK TOWER FRAMING.

Size of Tank:
18'-0" Diameter.
18'-0" Height.
Capacity 30,000 Gallons.
Weight 16,400 lbs.

For Tank Tower Framing
See Figures No 3 & 4.

DESIGN OF TANK BEAMS:

Weight of water = 30,000 x 8.33 = 250,000 lbs.

Weight of tank = 16,400 lbs.

Total Weight = 266,400 lbs.

Load per square foot = $\frac{266400}{254.5}$ = 1050 lbs. per sq. ft.

Space beams 2'-0" centers.

$R = 1050 \times 9.0 = 9450$ lbs.

$M = (9450 \times 7 - 1050 \times 9.0 \times \frac{9.0}{2})2 \times 12 = 591,000.$

$\frac{I}{C} = \frac{591,000}{16,000} = 37.$

Use 12" I beams weighing 31.5 lbs. per foot.

TANK TOWER WALLS:

(See Figure No 5).

Load on one wall = $\frac{266400}{2}$ = 133,200 lbs.

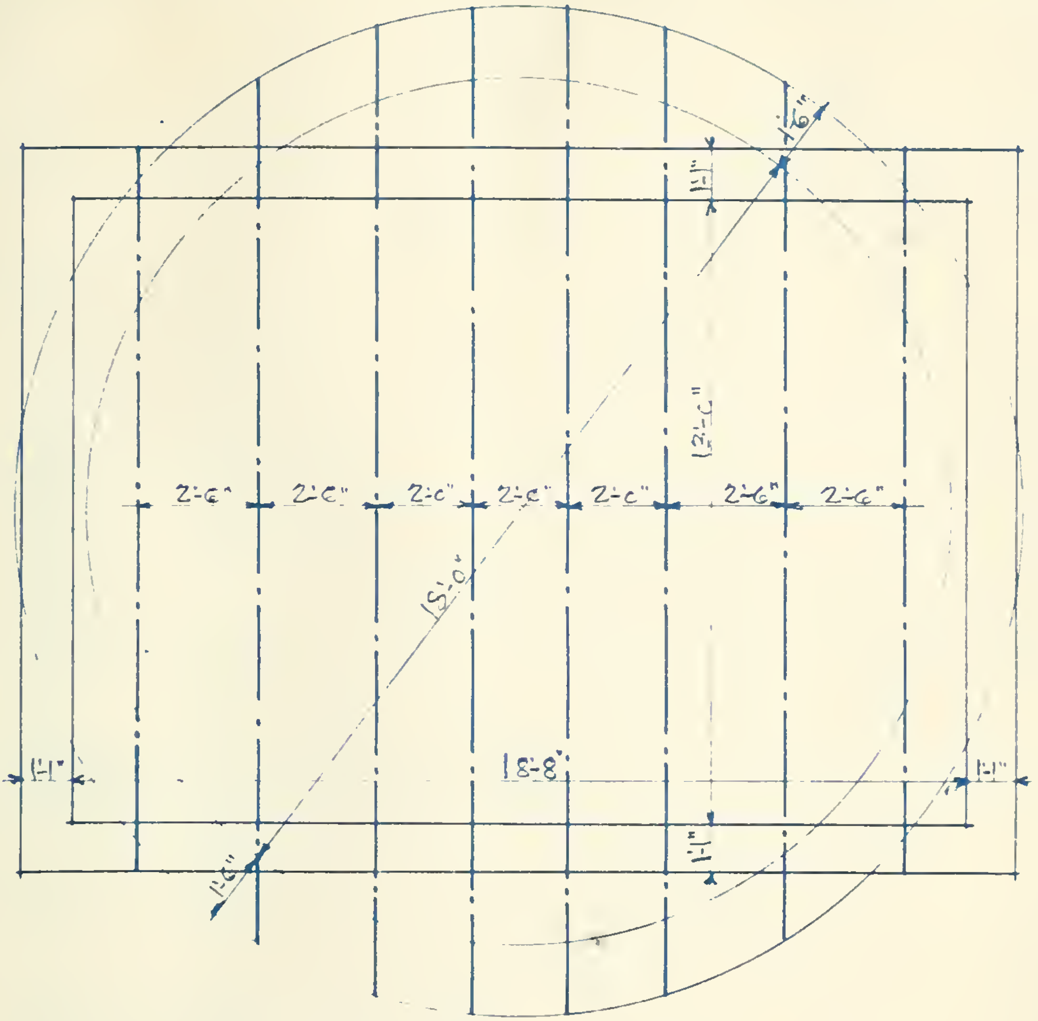
Load per foot of wall = $\frac{133,200}{19}$ = 7000 lbs.

Load at 6th Floor:
Tank = 7000 lbs.
Wall = 130 x 37 = 4810 "
Stair Load = 125 x 6.5 = 810 "
Total = 12620 lbs.

Load per square inch = $\frac{12620}{156}$ = 81 lbs. Which is OK.

Load at 3rd Floor:
From above = 12620 lbs.
Wall = 170 x 36 = 6120 "
Stair load = 3x125x6.5 = 2430 "
Total = 21170 lbs.

Load per square inch = $\frac{21170}{17x12}$ = 104 lbs.



TANK TOWER FRAMING

FIGURE NO. 3.

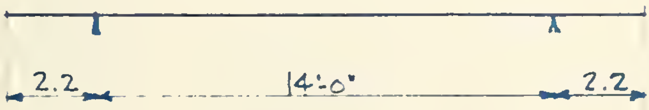
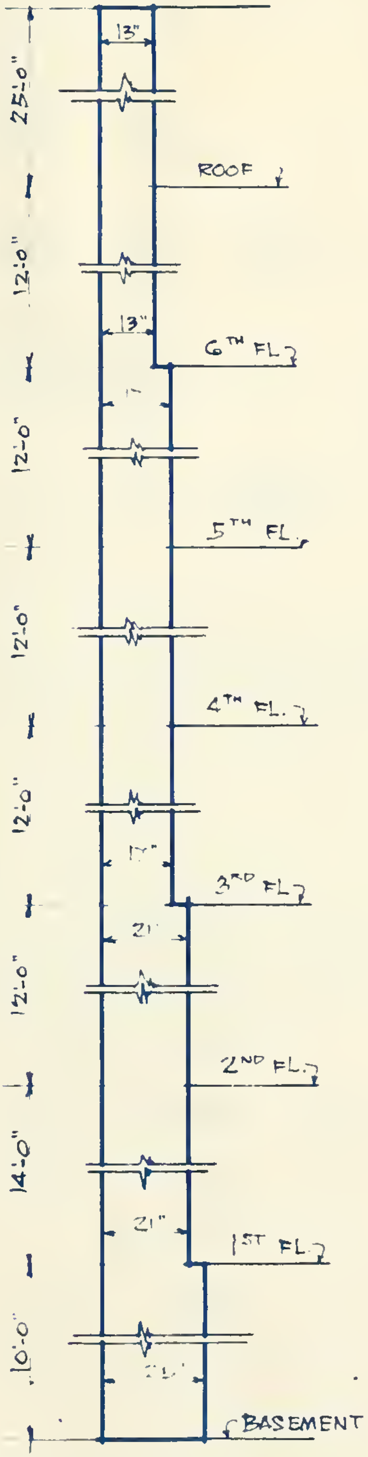


FIGURE NO. 4.



·TANK TOWER WALL·

FIGURE NO. 5

TANK TOWER WALLS (continued)

Load at 1st Floor:
From above = 21170 lbs.
Wall = 210 x 26 = 5460 "
Stair Load = 2x125x 6.5 = 1620 "
Total = 28250 lbs.

Load per square inch = $\frac{28250}{21x12}$ = 112 lbs.

Load at Basement:
From above = 28250 lbs.
Wall = 250 x 10 = 2500 "
Stair Load = 6.5 x 125 = 810 "
Total = 31560 lbs.

Load per square inch = $\frac{31560}{25x12}$ = 105 lbs.

Use walls as indicated.

NOTE: Where floor girder frames into tower wall, build pier at corner to receive such girder and make 8" projection in both sides of corner.

NOTE: For all other shaft walls use walls of ordinance thickness.

TYPICAL COLUMN FOUNDATIONS:

The building will be located on average Chicago soil, which is dirt fill for about four feet, then yellow clay, gradually changing to blue clay with gravel.

The basement of this building is about 7'-0" below grade, and bottom of footings will come about 3'-6" below basement floor line. Therefore we can expect to find at this elevation a mixed blue and yellow clay strata, which will have a bearing capacity of about 3500 lbs. per square foot, according to Chicago ordinance:

TYPICAL COLUMN FOUNDATIONS (continued)

"ALLOWABLE STRESSES AND SPECIAL REQUIREMENTS FOR FOUNDATIONS-BEARING ON VARIOUS SOILS.)

(a) If the soil is a layer of pure clay at least fifteen feet thick, without admixture of any foreign substance other than gravel, it shall not be loaded to exceed 3,500 pounds per square foot. If the soil is a layer of pure clay at least fifteen feet thick and is dry and thoroughly compressed, it may be loaded not to exceed 4,500 pounds per square foot.

(b) If the soil is a layer of firm sand fifteen feet or more in thickness, and without admixture of clay, loam or other foreign substance, it shall not be loaded to exceed 5,000 pounds per square foot.

(c) If the soil is a mixture of clay and sand, it shall not be loaded to exceed 3,000 pounds per square foot."

BASE.

Load on basement columns = 329,000 lbs.

Area of base required = $\frac{329000}{400}$ = 822.5 square inches.

Make base 30" x 30" at bottom.

Top of base same size as column. (See Figure No. 6)

FOOTINGS.

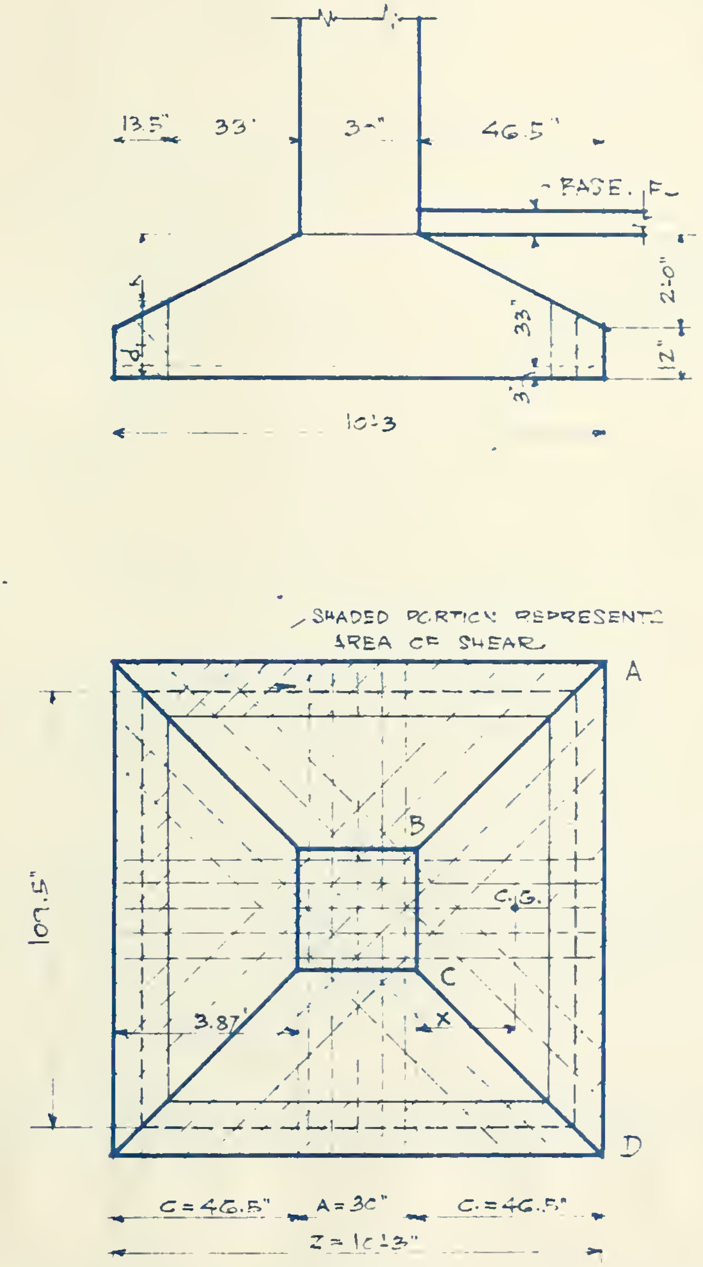
Column Load on Footing = 329,000 lbs.

Approx. Weight of Footing 30,000 "

Total Load = 359,000 lbs.

Area of Footing required = $\frac{359,000}{3500}$ = 102.6 square feet.

Make Footing, 10'-3" x 10'-3", Area = 105.0 square feet.



TYPICAL COLUMN FOOTING.

FIGURE NO. 6.

TYPICAL COLUMN FOUNDATIONS (continued)

DESIGN OF FOOTING:

Area of base = 2.5 x 2.5 = 6.25 sq. ft., say 6 sq. ft.

Net area of footing = 105 - 6 = 99 square feet.

"X" = distance of center of gravity of "ABCD" from "BC" (See Figure No. 6).

$$"X" = \frac{\frac{ac}{2} + \frac{2}{3}c^2}{a + c} = \frac{2.5 \times \frac{3.875}{2} + \frac{2}{3} \times 3.87 \times 3.87}{2.5 + 3.87} = 2.33 \text{ ft}$$

Total Moment around column perimeter =

99 x 3500 x 2.33 x 12 = 9,702,000 inch lbs.

$M_c = \frac{1}{6}bd^2f_c$. $d^2 = \frac{9702000 \times 6}{30 \times 4 \times 650} = 746$. d = 27.5 inches.

Use d = 33 inches. D = 36 inches.

$M_s = \frac{7}{8}df_sA$. $A = \frac{9702000 \times 8}{7 \times 33 \times 18000} = 18.6$ square inches.

Amount of steel required in each band = $\frac{18.6}{8} = 2.33$ sq. in

Use five 3/4 inch square bars in each band.

SHEAR.

Point at which to calculate shear is 33 inches from BC.

$d' = 33 - k = 33 - \frac{33 \times 24}{46.5} = 16$ inches.

Total Shear $V = \frac{109.5 \times 13.5 \times 3500}{144} = 35,900$ lbs.

v = Unit Shear $= \frac{35900}{96 \times .875 \times 16} = 27$ lbs. per sq. inch.

No stirrups required.

PUNCHING SHEAR.

$P = \frac{99 \times 3500}{4 \times 30 \times .875 \times 33} = 100$ lbs. per square inch.

Chicago Building Ordinance allows a punching shear of 120 lbs. per square inch.

TYPICAL COLUMN FOUNDATIONS (continued)

DESIGN OF FOOTING (continued)

PIER FOOTINGS:

Load on Pier = 350000 lbs.

Approximate weight of Footing = 32000 " (See Page No. 122).

Total = 382000 lbs.

Area of Footing required = $\frac{382000}{3500}$ = 109 square feet.

Use Footing 8'-9" x 12'-6". Area = 109 square feet.

$$x = \frac{2.75 \times \frac{2.75}{2} + \frac{2}{3}(2.75)^2}{2.75 + 2.75} = 1.6.$$

$$y = \frac{3.5 \times 3 + \frac{2}{3} \times 9}{7 + 3} = 1.65.$$

$$A_x = \frac{2'9" + 8'9"}{2} \times 2'9" = 15.81.$$

$$A_y = \frac{7'0" + 12'6"}{2} \times 3'0" = 29.25.$$

Taking moments for each cantilever section of footing, we will get -

M_x = 15.8 x 3500 x 1.6 x 12 = 1,061,700 inch lbs.

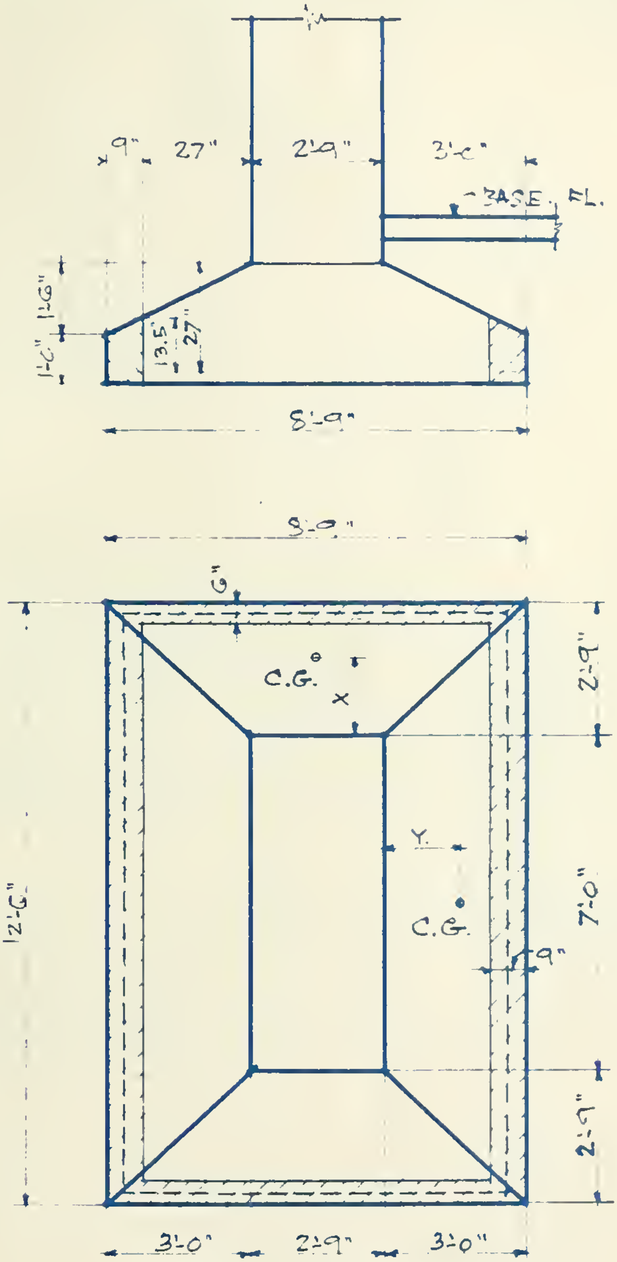
M_y = 29.25x3500x1.65x12 = 2,027,000 inch lbs.

$$d_x = \sqrt{\frac{1,061,700 \times 6}{650 \times (2.75 \times 12)}} = 17 \text{ inches.}$$

$$d_y = \sqrt{\frac{2,027,000 \times 6}{650 \times (7 \times 12)}} = 15 \text{ inches.}$$

In order not to have excessive shear and to reduce the amount of reinforcing steel we will use a deeper footing than the above.

Use d = 27 inches. D = 2'-6".



TYPICAL PIER FOOTING.

FIGURE NO. 7.

TYPICAL COLUMN FOUNDATIONS (continued)

PIER FOOTINGS (continued)

LONGITUDINAL SECTION:

$$A_s = \frac{1,061,700 \times 8}{7 \times 27 \times 18000} = 2.5 \text{ square inches.}$$

Use seven 5/8" square twisted bars.

$$V = \frac{96 \times 6 \times 3500}{144} = 14000 \text{ lbs.}$$

$$v = \frac{14000}{87 \times .875 \times 12,25} = 15 \text{ lbs. per square inch.}$$

PUNCHING SHEAR:

$$p = \frac{15.81 \times 3500}{27 \times 33 \times .875} = 71 \text{ lbs. per square inch.}$$

CROSSWISE SECTION:

$$A_s = \frac{2,027,000 \times 8}{7 \times 27 \times 18000} = 4.8 \text{ square inches.}$$

Use fourteen 5/8" square twisted bars.

$$V = \frac{144 \times 9 \times 3500}{144} = 31500 \text{ lbs.}$$

$$v = \frac{31500}{138 \times .875 \times 13.5} = 19.5 \text{ lbs. per square inch.}$$

PUNCHING SHEAR:

$$p = \frac{29.25 \times 3500}{27 \times 84 \times .875} = 53 \text{ lbs.}$$

FOOTINGS FOR DRIVEWAY COLUMNS.

Reaction from Girders = 320000 lbs.
Weight of column = 2000 "
Weight of footing = 25000 "
Total load = 347000 lbs.

Area of footing required = $\frac{347000}{3500}$ = 100 square feet.

Make footing 10 feet by 10 feet.

Base plate of Column: = $\frac{322000}{400}$ = 805 square inches.

Make plate 2'6" x 2'6" x 1".

Area "ABCD" = $(2.5 + 10)\frac{1}{2} \times 3.75 = 23.5$.

$W = 23.5 \times 3500 = 83000$.

$x = \frac{3.75}{3} \times \frac{(2.5 + 20)}{(12.5)} = 2.25$.

$M = 83000 \times 2.25 \times 12 = 2240000$ inch lbs.

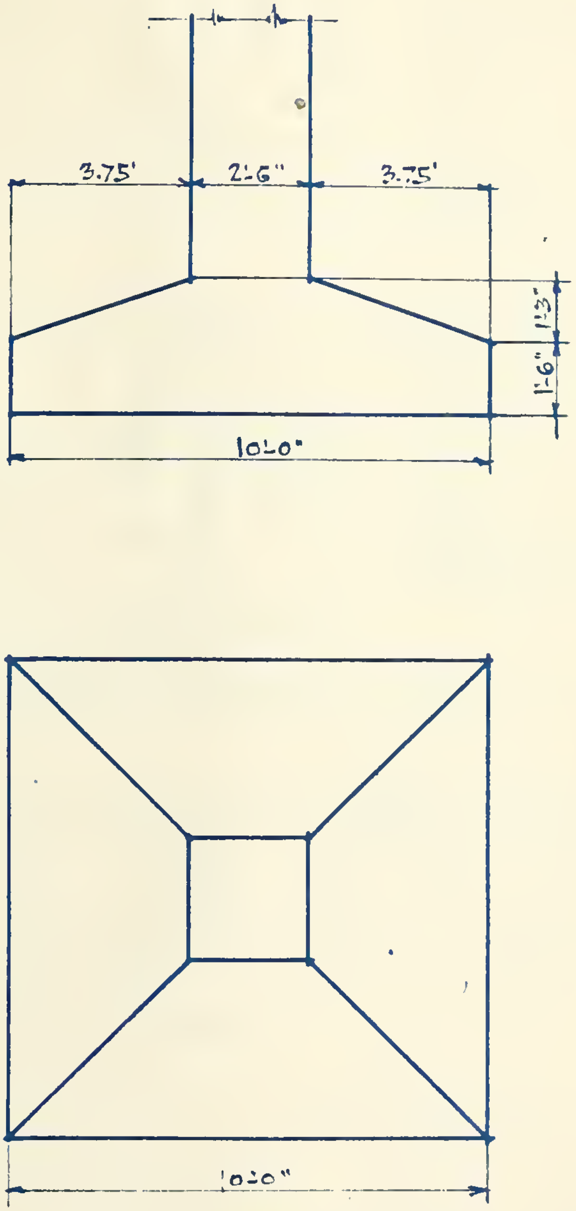
$d = \sqrt{\frac{2240000 \times 6}{30 \times 650}} = 26.3$. Use $d = 30"$. $D = 33"$.

$A = \frac{2240000 \times 8}{7 \times 18000 \times 30} = 4.73$ sq.in. Use twenty 3/4" bars.

PUNCHING SHEAR.

Punching shear = $\frac{83000}{30 \times 30}$ = 92 lbs, which is "O.K."

Since punching shear is O.K., vertical shear will be O.K.



·DRIVEWAY FOOTING.

FIGURE NO.12

WALL FOOTINGS:

NORTH WALL - FACING ALLEY-

Joists and lamination rest on wall.

FLOOR LOADS:

Roof load = 50 x 8.5 = 425 lbs.
6th Floor load = 195 x 8.5 = 1660 "
5th " " = 185 x 8.5 = 1570 "
4th " " = 175 x 8.5 = 1490 "
3rd " " = 165 x 8.5 = 1400 "
2nd " " = 192.5 x 8.5 = 1635 "
1st " " = 180 x 8.5 = 1560 "
Total 9740 lbs. 9740 lbs.

WALL LOADS:

Roof = 130 x 5 = 650 lbs.
6th Floor = 170 x 12 = 2040 "
5th " = 170 x 12 = 2040 "
4th " = 170 x 12 = 2040 "
3rd " = 210 x 12 = 2520 "
2nd " = 210 x 12 = 2520 "
1st " = 210 x 14 = 2940 "
Basement = 310 x 10 = 3100
Total 17850 lbs 17850 lbs.

Total Load per foot of wall 27590 lbs.

Weight of footing (Approximately) 2010 "

Total 29600 lbs.

Width of footing required = $\frac{29600}{3500}$ = 8.45 feet.

Use footing 8'-6" wide (See Figure No. 8).

$M = \frac{1}{2} \times 3500 \times 3.20 \times 3.20 \times 12 = 215{,}000$ inch lbs.

$d = \sqrt{\frac{215000 \times 6}{650 \times 12}} = 12.8.$

Make d = 21 inches. D = 24 inches.

$A = \frac{215000 \times 8}{7 \times 18000 \times 21} = .65$

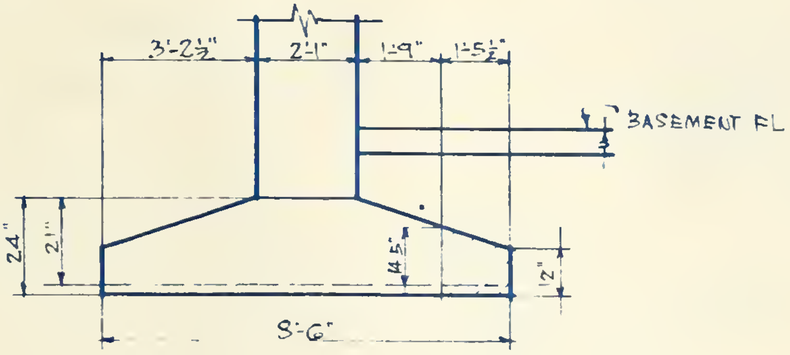
Use 3/4 inch square bars at 10 inch centers.

Use four 1/2 inch bars longitudinally, spaced about 2'-0" centers.

SHEAR.

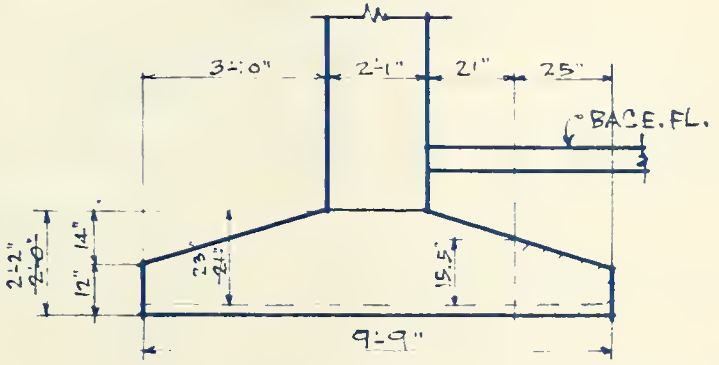
$V = 3500 \times 1.45 = 5100.$ $v = \frac{5100}{12 \times .875 \times 14.5} = 33.6$

PUNCHING SHEAR. $\frac{3500 \times 3.2}{21 \times .875 \times 12} = 51$ lbs.



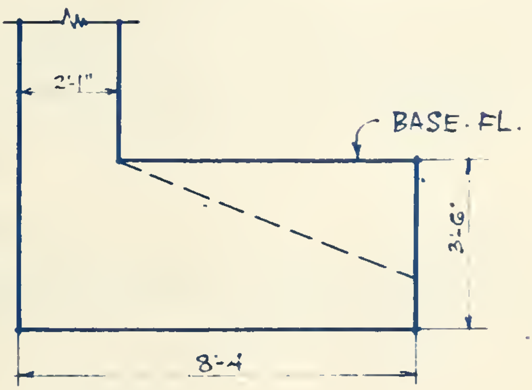
WALL FOOTING.

FIGURE NO. 8



WALL FOOTING.

FIGURE NO. 9



WALL FOOTING.

FIGURE NO. 10.

TANK TOWER WALL FOOTINGS.

DESIGN OF WALLS carrying steel beams under tank.

Load on footing per lineal foot of wall = 31560 lbs (See page 128)

Weight of footing (Approximately) = 2500 "

Total Load = 34060 lbs.

Width of Footing required $= \frac{34060}{3500} = 9'\text{-}9"$.

Make Footing 9'-9" wide. (See Figure No. 9.).

$M = \frac{1}{2} \times 3500 \times (3'10")^2 \times 12 = 310000$ inch lbs.

$d = \sqrt{\frac{310000 \times 6}{12 \times 650}} = 15.4"$.

Make d = 21 inches. D= 24 inches.

$A = \frac{310000 \times 8}{7 \times 18000 \times 21} = .94"$.

Use 3/4" square twisted bars. 7 inch centers.

VERTICAL SHEAR.

$V = 3500 \times 2.08 = 7280$ lbs.

$v = \frac{7280}{12 \times .875 \times 15.5} = 44.5$ lbs.

Since allowable unit shear of 40 lbs. is exceeded by 4.5 lbs., we will increase depth of footing by two inches, which undoubtedly will take care of this excessive shear.

PUNCHING SHEAR.

$P = \frac{3500 \times 3.83}{23 \times .875 \times 12} = 56$ lbs.

WALL FOOTINGS:

SOUTH WALL -

This being a lot line wall, cantilever footing will have to be used.

Load = 29000 lbs. per foot of wall.

Width of footing required = 8'-4". (See Figure No. 10)

MOMENT:

$$M = 3500 \times (8'4'' - 2'1'')^2 \times 12 \times \frac{1}{2} = 820000 \text{ inch lbs.}$$

$$d = \sqrt{\frac{820000 \times 6}{12 \times 650}} = \sqrt{630} = 25.2''$$

Make $d = 3'\text{-}3''$. $D = 3'\text{-}6''$.

$$A = \frac{820000 \times 8}{7 \times 18000 \times 39} = 1.33 \text{ square inches.}$$

Use 1" square twisted bars, 9" centers.

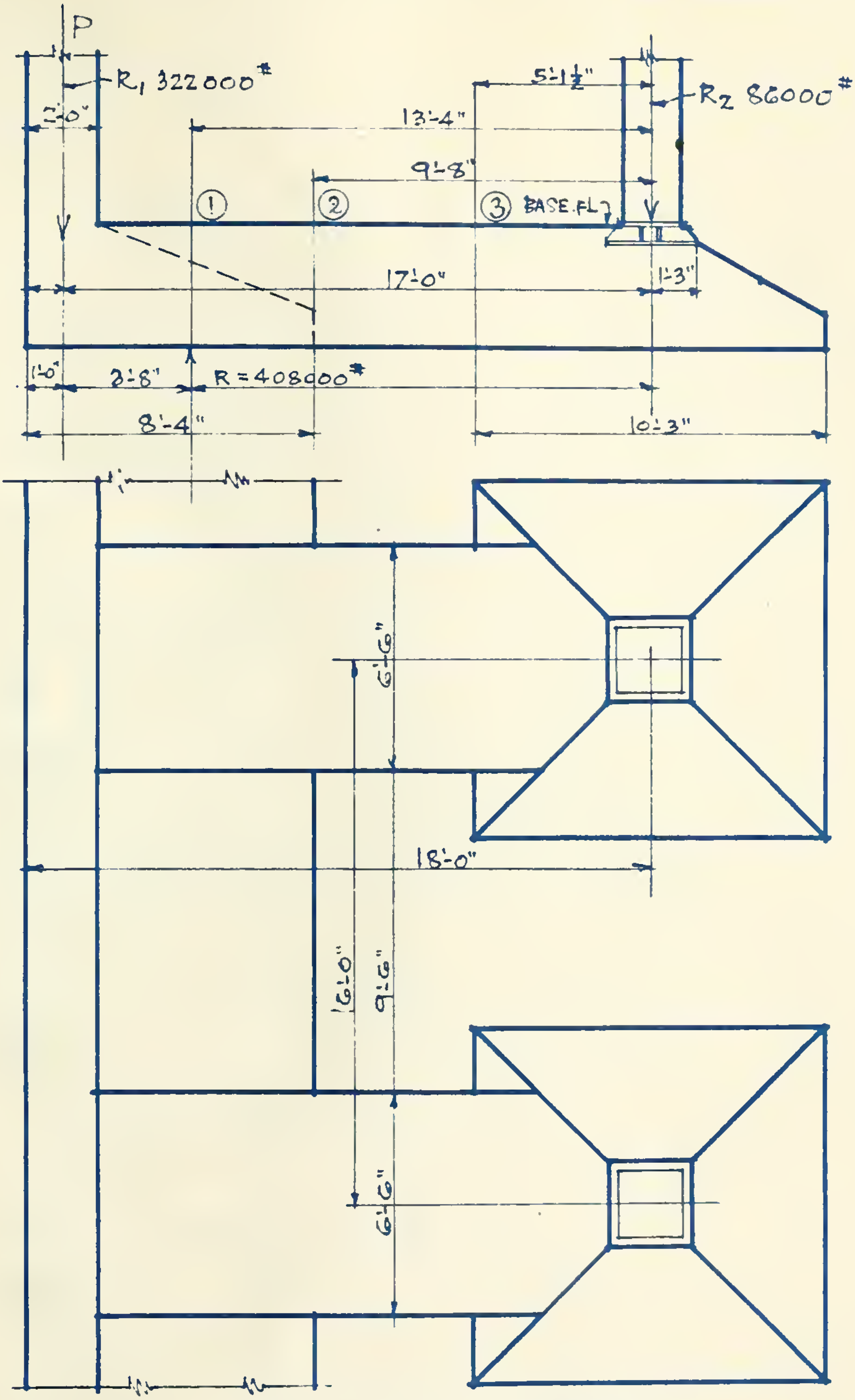
SHEAR:

$$V = 3500 \times (8'4'' - 2'1'') = 21875 \text{ lbs.}$$

$$v = \frac{21875}{12 \times 39 \times .875} = 54 \text{ lbs.}$$

Since allowable unit shear is 40 lbs., stirrups must be provided to take care of the shear.

It is not good practice to have large footings of the cantilever type without some means of tying such footings to the buildings. Therefore, we will place concrete beams between the wall footings and the first row of column footings. The beams will be designed for eccentric load, and the footing between the beams as an ordinary slab. (See Figure No. 11).



CANTILEVER WALL FOOTING.

FIGURE NO.11.

WALL FOOTINGS: (continued)

SOUTH WALL - (continued)

SLAB:

Load = 3500 lbs. per lineal foot of footing.

Span = 16'-0", center to center of columns.

Net Span = 16'-0" minus 6'-6" = 9'-6". (See Page 140).

M = 1/8 x 3500 x 9.5 x 9.5 x 12 = 475,000 inch lbs.

$$d = \sqrt{\frac{475000 \times 6}{12 \times 650}} = 19 \text{ inches.}$$

Use d = 39". (See Shear).

$$A_s = \frac{475000 \times 8}{7 \times 18000 \times 39} = .77.$$

Use 3/4" square bars at 8" centers.

SHEAR:

At beam = 3500 x 4.75 = 16,650 lbs.

$$v = \frac{16650}{39 \times 12 \times .87} = 41 \text{ lbs.}$$

Therefore no shear reinforcement will be necessary.

BEAM: (See Figure No. 11).

P = 29000# x 16 = 464,000 lbs.

R = 464000 - (16 x 1 x 3500) = 408,000 lbs.

$$R_1 = 408000 \times \frac{13.33}{17} = 322,000 \text{ lbs.}$$

R_2 = 408000 - 322000 = 86,000 lbs.

Assume Beam = 3'-6" deep.

M = 322000# x 44 = 14,168,000 inch lbs.

$$A_1 = \frac{14168000 \times 8}{7 \times 18000 \times 40} = 22.5 \text{ square inches.}$$

WALL FOOTINGS (continued)

SOUTH WALL (continued)

WIDTH OF BEAM REQUIRED:

$$b = \frac{14168000 \times 6}{700 \times 40 \times 40} = 76 \text{ inches.}$$

Make beam 3'-6" deep and 6'-6" wide.

Area of beam = 78 x 42 = 3276 square inches, which will develop at least 1% of steel reinforcing.

$$A_2 = 22.5 \text{ sq.in.} \times \frac{9.66}{13.33} = 16.3 \text{ square inches.}$$

$$A_3 = 22.5 \text{ sq.in.} \times \frac{5.12}{13.33} = 8.65 \text{ square inches.}$$

Use steel

Nine 1 inch square twisted bars, 27'-0" long, bent up into wall and through column footing.

Nine 1 inch square twisted bars, 18'-0" long, bent up into wall.

Six 1 inch square twisted bars, 14 feet long, bent up into wall.

SHEAR:

$$\text{at "3"} = \frac{86000}{40 \times 78 \times .87} = 32 \text{ lbs.}$$

ELEVATOR WALL FOOTINGS.

SOUTH WALL.

Roof = 45 x (1'6" + 5'6") = 320 lbs.

$$\text{Floors} = \left.\begin{array}{l} 195 \\ 185 \\ 175 \\ 165 \\ 192.5 \\ 180 \end{array}\right) \times 1'6" = 1640 \text{ "}$$

Wall = 130 x 40 = 5200 "

" = 170 x 38 = 6500 "

" = 210 x 10 = 2100

Total Load (roof, floors and walls) = 15760 "

Weight of Footing = 750 "

Total Load (including footing) = 16520 lbs.

Width of footing required = $\frac{16520}{3500}$ = 4.75 feet.

Make footings 5'0" wide.

Projection = $\frac{5'0" - 1'9"}{2} = 19\frac{1}{2}$ inches.

M = 3500 x 19.5 = 68500 inch lbs.

$d^2 = \frac{68500 \times 6}{12 \times 650} = 53$ inches. d = 7 inches.

Make footing = 2'6" deep.

$A = \frac{68500 \times 8}{7 \times 18000 \times 27} = .16.$

Use 1/2 inch square twisted bars, 12 inch centers.

DESIGN OF CHIMNEY STACK.

Height = 110 feet (Assumed for draft).

Size 2'6" square in the clear.

Use 4" fire brick and 3" air space around flue,
for a height of 30'-0" (See Ordinance.)

Ordinance thickness of walls will be used.

For section of stack, see Figure No. 13 .

Weight per foot of wall:

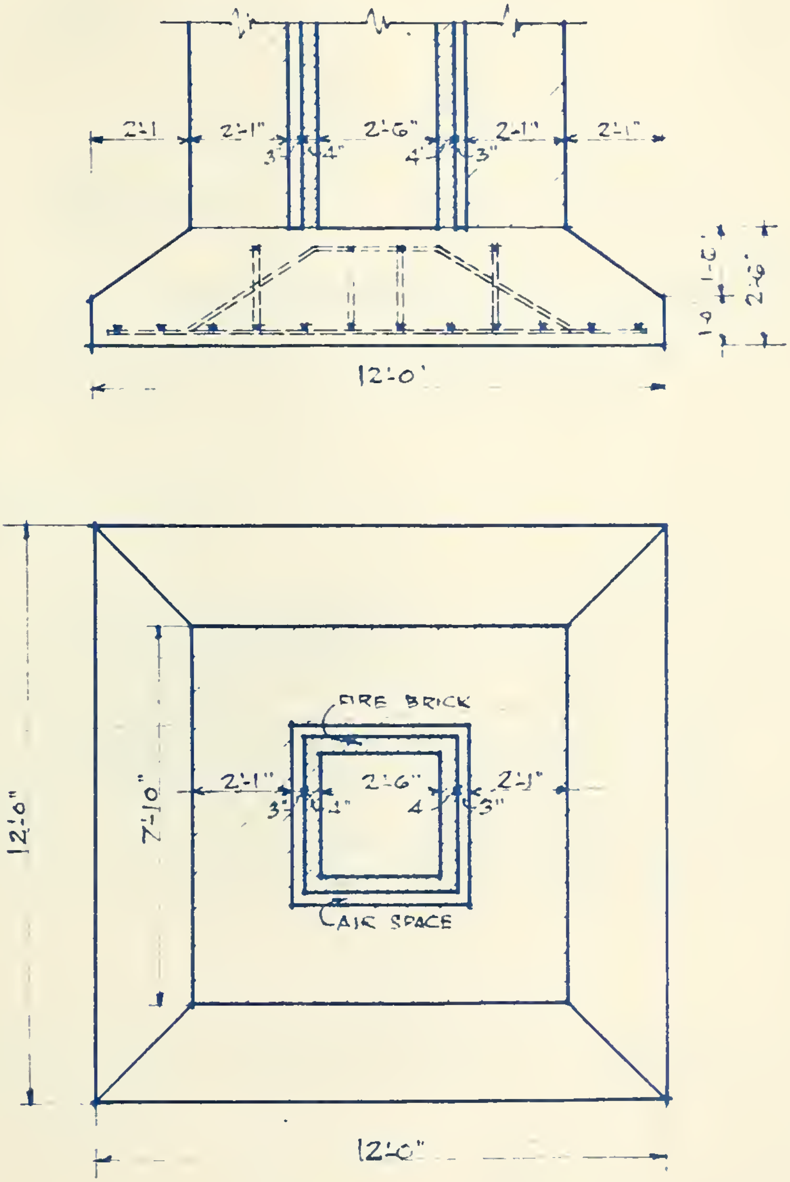
120 x 26 = 3120 lbs.
170 x 36 = 6120 "
210 x 38 = 7980 "
250 x 10 = 2500 "
Total = 19720 "

Total weight of wall:

19720 [7'10" x 2+2(7'10" - 4'2")] =	453500 lbs.
Weight of fire brick = 40 x 50 x 6'10"	14000 "
Foundations, (assumed)	35000 "
Total	502500 "

Bearing area required = $\frac{502500}{3500}$ = 143 square feet.

Use footing 12 feet by 12 feet.



· STACK FOOTING ·

FIGURE NO. 13.

DESIGN OF FOOTING.

$$M = \frac{1}{2}wL^2 = \frac{1}{2} \times 3500 \times \overline{2.08}^2 \times 12 = 90500 \text{ inch lbs.}$$

$$d = \sqrt{\frac{90500 \times 6}{650 \times 12}} = 8.5.$$

Use d = 2'-3".   D = 2'-6".

$$A = \frac{90500 \times 8}{7 \times 18000 \times 27} = .213 \text{ square inches.}$$

Use $\frac{1}{2}$ inch square twisted bars at 12 feet centers, both ways. Bend alternate bars.

DESIGN OF CENTER PORTION.

$$M = \frac{1}{8}wL^2 = \frac{1}{8} \times 3500 \times 2.5 \times 2.5 \times 12 = 32800 \text{ inch lbs.}$$

$$A_s = \frac{32800 \times 8}{7 \times 18000 \times 27} = .078 \text{ square inches.}$$

Bent up alternate bars will take care of this moment.

DESIGN OF LINTELS:

(SEE FIGURE NO. 14 to 17)

LINTEL No. 1.

Typical Curtain Walls.
12'-0" Openings.
1'-1" Wall.
No floor.

Load = 130 lbs. x 12 x 4.5 = 7020 lbs.

Use 7 inch I beam 15#.

Plate 12" x 3/8".

LINTEL No. 2.

Windows in North Wall (alley)
8'-0" Openings.
1'-5" Wall.
6th Floor.

Wall = 170 x 8 x 4.5 = 6120 lbs.

Roof = 50 x 9 x 8 = 3600 "

Total = 9720 lbs.

Use 2-6" channels 8#.

One plate 16" x 1/4".

LINTEL No. 3.

Windows in North Wall.
8'-0" Openings.
1'-5" Wall.
3rd, 4th 4nd 5th Floors.

Wall = 170 x 8 x 4.5 = 6120 lbs.

Floor= 225 x 8 x 9 =16200 "

Total 22320 lbs.

Use one 8" I beam 18#.

One 8" channel, 11.25#.

One plate 16" x 1/4".

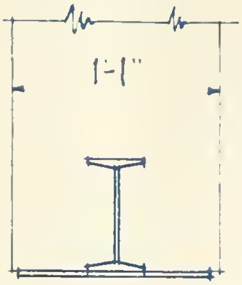


FIGURE NO. 14.

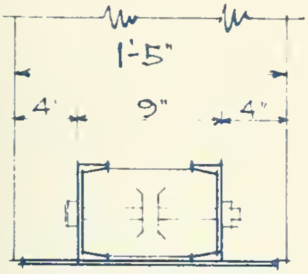


FIGURE NO. 15.

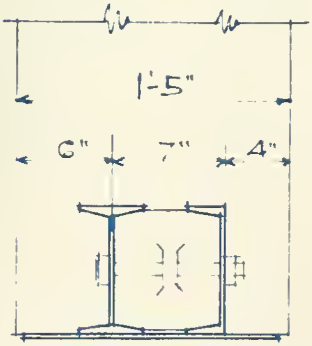


FIGURE NO. 16.

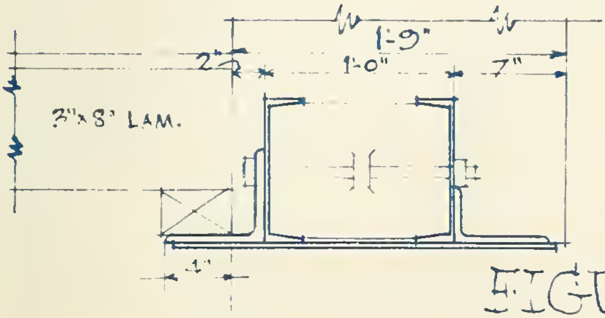


FIGURE NO. 17.

DESIGN OF LINTELS: (continued)

LINTEL No. 4.

Windows in North Wall.
8'-0" Openings.
1'-9" Wall.
Basement, 1st and 2nd Floors.

Wall = 210 x 8 x 4.5 = 7560 lbs.

Floor= 280 x 8 x 9 = 20160 "

Total = 27720 lbs.

Use two 9" channels, 13.25#.

One 6" x 6" x 5/8" angle.

One 6" x 3-1/2" x 3/8" angle.

One plate 24" x 3/8".

FORMULAE USED IN BUILDING DESIGN,
IN ACCORDANCE WITH
THE CHICAGO BUILDING ORDINANCE.

BEAMS:

Timber - Safe Load = $\frac{bd^2\ f}{9\ L}$.

Concrete - $M_s = f_s A \frac{7}{8} d$.

$M_c = \frac{1}{6} f_c bd^2$.

COLUMNS:

Steel. $f = 16000 - 70\frac{l}{r}$.

Wrought iron $= 12000 - 60\frac{l}{r}$.

Cast iron $= 10000 - 60\frac{l}{r}$.

Steel encased in concrete $= 18000 - 70\frac{l}{r}$.

Timber $= c(1 - \frac{L}{80\ D})$.

CONCRETE SLAB:

$M = \frac{1}{8} wL^2$ for end slab.

$M = \frac{1}{10} WL^2$ for partially continuous slab.

$M = \frac{1}{12} WL^2$ for totally continuous slab.

GENERAL FORMULAE FOR FLEXURE OF BEAMS.

Notation.

A = area of section in square inches.
b = breadth of beam in inches.
C = coefficient of strength.
d = depth of beam in inches.
D = deflection of beam in inches due to loads W or P.
E = modulus of elasticity in pounds per square inch.
f = stress in pounds per square inch in extreme fibres.
I = moments of inertia in inches.
L = span in feet.
l = span in inches.
M = bending moment.
N = coefficient of deflection.
n = distance of center of gravity of section from extreme fibre, in inches.
P = load in pounds concentrated at any point.
S = section modulus in inches.
s = allowable shear in direction of the grain, in pounds per square inch.
W = load in pounds uniformly distributed.
w = load in pounds per lineal foot of span.

FORMULAE.

For rectangular or square beams with neutral axis perpendicular to the depth at center:

$I = \frac{bd^3}{12}$. $S = \frac{I}{n} = \frac{bd^2}{6}$. $M = fS$.

SAFE LOADS.

(I) For beam supported at both ends and uniformly loaded:

(1) $M = \frac{Wl}{8}$, hence $W = \frac{8fS}{l}$.

(2) $C = \frac{8fS}{l}$, where $l = 12"$, therefore $C = \frac{2fS}{3}$.

GENERAL FORMULAE FOR FLEXURE OF BEAMS-(continued)

SAFE LOADS (continued)

(II) For beam supported at both ends with concentrated load applied at center of span:

(3) $M = \frac{Pl}{4}$, hence $P = \frac{4fS}{l}$.

(4) $C = \frac{4fS}{l}$, where $l = 12"$, therefore $C = \frac{fS}{3}$.

(III) For beam supported at both ends with concentrated load applied in two equal parts at third points of span:

where P = sum of the two equal loads,

(5) $M = \frac{P}{2} \times \frac{l}{3}$, hence $P = \frac{6fS}{l}$.

(6) $C = \frac{6fS}{l}$ where $l = 12"$, therefore $C = \frac{fS}{2}$.

The safe load for any span in feet $= \frac{C}{L}$, C corresponding to the manner of loading.

DEFLECTIONS.

(IV) For beam supported at both ends and uniformly loaded:

(7) $D = \frac{5Wl^3}{384EI}$, hence for square or rectangular beams,

(8) $D = \frac{270 \times WL^3}{Ebd^3}$.

(V) To find the load which will cause a deflection of one-thirtieth of an inch per foot of span make $D = \frac{L}{30}$, hence

(9) $W = \frac{Ebd^3}{8100\ L2}$.

GENERAL FORMULAE FOR FLEXURE OF BEAMS-(continued)

DEFLECTIONS (continued)

(VI) For a beam supported at both ends with concentrated load applied at center of span:

(10) $D = \frac{Pl^3}{48EI}$, hence for a square or rectangular beam,

(11) $D = \frac{432Pl^3}{Ebd^3}$.

(VII) To find the load which will cause a deflection of one-thirtieth of an inch per foot of span, make $D = \frac{L}{30}$ hence

(12) $P = \frac{Ebd^3}{12960L^2}$.

(VIII) For a beam supported at both ends with teo equal concentrated loads applied at the third points of the span:

where P = the sum of the two equal loads

(13) $D = \frac{23Pl^3}{1296EI}$, hence for a square or rectangular beam

(14) $D = \frac{368WL^3}{Ebd^3}$.

(IX) To find the load which will produce a deflection of one-thirtieth of an inch per foot of span make $D = \frac{L}{30}$, hence

(15) $P = \frac{Ebd^3}{11040L^2}$.

GENERAL FORMULAE FOR FLEXURE OF BEAMS-(continued)

COEFFICIENT OF DEFLECTION.

The coefficients of deflection given in the tables of properties of beams, mill and laminated floors were obtained by the following formulae:

(X) For uniformly distributed load (7):

(16) $\frac{Wl^3}{76.8EI}$.

(XI) For load concentrated at center of span (10):

(17) $\frac{Pl^3}{48EI}$.

(XII) For two equal loads concentrated at third points of span, (total load = P), (13):

(18) $\frac{23Pl^3}{1296EI}$.

In all of the above,

W and P = 1000 pounds.

l = 12 inches.

These coefficients are the deflections in inches, of a beam one foot long with a load of 1000 pounds.

The deflection of a beam for any load and span is the product of the proper coefficient, the cube of the span in feet and the number of 1000 pound units in the given load.

MAXIMUM SPANS FOR BEAMS,

MILL AND LAMINATED FLOORS.

(XIII) For a beam supported at both ends and uniformly loaded:

the uniformly distributed load = wL.

(19) $\frac{wL^2}{8} = \frac{fS}{12}$ hence

(20) $L^2 = \frac{2fS}{3w}$.

(XIV) For a beam supported at both ends with concentrated load applied at center of span:

(21) $\frac{PL}{4} = \frac{fS}{12}$ hence

(22) $L = \frac{fS}{3P}$.

(XV) For a beam supported at both ends with two equal concentrated loads applied at the third points of span:

P = sum of two equal loads

(23) $\frac{PL}{6} = \frac{fS}{12}$, hence

(24) $L = \frac{fS}{2P}$.

GENERAL FORMULAE FOR FLEXURE OF BEAMS-(continued)

SPANS LIMITED BY A GIVEN DEFLECTION.

Deflection limited to one-thirtieth of an inch per foot of span.

(XVI) For a beam supported at both ends and uniformly loaded:

In formula (9) make $W = wL$ hence

(25) $$L^3 = \frac{Ebd^3}{8100\ w}.$$

(XVII) For a beam supported at both ends with concentrated load applied at center of span:

From formula (12)

(26) $$L^2 = \frac{Ebd^3}{12960\ P}.$$

(XVIII) For a beam supported at both ends with two equal concentrated loads applied at the third points of span:

From formula (15)

P = the sum of the two equal loads.

(27) $$L^2 = \frac{Ebd^3}{11040\ P}.$$

HORIZONTAL SHEAR.

The intensity of the shearing stress at any point in a section is the same for the vertical shear and the horizontal shear.

The maximum horizontal shear for a square or rectangular beam, per unit of neutral surface, is

$$(28)\quad H = \frac{3V}{2bd},$$

in which

V = the vertical shear in the section.

For symmetrically loaded beams substitute $\frac{W}{2} = V$ and substitute $s = H$, then the safe load limited by the resistance to horizontal shear is

$$(29)\quad W = \frac{4bds}{3}.$$

The load limited by the resistance to horizontal shear is the maximum load that can be safely applied to the beam.

SPECIFICATIONS.

The following specifications cover the items of General Conditions, Masonry, Reinforced Concrete, Carpentry, Structural Steel and Iron, Fireproof Doors, Fireproof Windows, Composition Roofing and Automatic Sprinkler System.

They are intended to cover only the Structural and Fireproofing features of the building.

No attempt is made to give a complete set of specifications, covering the entire job, and therefore, the items of Sheet Metal, Lathing and Plastering, Glass and Glazing, Painting, Elevators, Electric Wiring, Steam Heating, and Plumbing and Sewerage and not included.

SPECIFICATIONS

COVERING AND APPLYING TO ALL KINDS OF MATERIALS AND ALL BRANCHES OF WORK FOR A WAREHOUSE BUILDING TO BE CONSTRUCTED AT CHICAGO, ILLINOIS, ACCORDING TO DRAWINGS AND SPECIFICATIONS.

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GENERAL CONDITIONS.

The Owner reserves the right to accept any or reject any or all bids.

COMPENSATION AND LIABILITY INSURANCE

The Contractor shall, at his own expense, comply with all requirements of the Workman's Compensation Act of the State of Illinois and any Amending Acts thereof, so as to effectually protect the Owner against any and all liability under and by virtue of said statute.

The Contractor shall, in addition, protect the Owner against loss or claim for damages to persons or property, which may result from the execution by the Contractor of the work of his contract.

CONSTRUCTION PERMITS.

The Contractor for Masonry, Cut Stone and Concrete work will procure and pay for water, street and building permits and bonds and inspection fees on plumbing fixtures.

Each other Contractor shall procure and pay for all other permits, bonds, indemnity, inspection, etc., required for the execution of the work of his contract.

REMOVAL OF RUBBISH.

The Contractor shall remove all rubbish and rejected material as same accumulates from all work and shall endeavor to maintain the building in a neat and orderly manner during construction.

EXTRA WORK.

The Owner will not pay for any extra work unless, before beginning such work, the Contractor first obtains a written order signed by the Engineer and Owner, specifying the agreed price for and the character and amount of such extra work.

RESPONSIBILITY OF CONTRACTORS.

This Contractor will be held responsible for all violations of City Ordinances and Laws and must repair or make good all damages to public or private property adjoining. This Contractor must see that the work and operations of adjoining property owners are not interfered with.

SHORING.

This Contractor must provide sufficient shoring, underpinning and other supports for all property adjacent to or in this building upon which the work or operation of the adjoining property owners depend. This will include the railroad tracks, paving, sidewalk, etc.

FEES FOR PATENTED INVENTIONS.

All fees or royalties for any patented invention, article, or arrangement that may be based upon, incorporated in, or may be in any manner connected with the work which is to be furnished under these specifications, shall be included in the contract price, and paid by the Contractor, and the Contractor shall for all time save harmless and indemnify the Owner for all costs, expenses, attorneys or solicitors' fees and damages, which the Owner may incur by reason of any infringement of any patent or patents or any inventions, article, arrangement or systems or system used in the construction, completion or use of the building.

SUB-CONTRACTORS.

All provisions and conditions of these specifications and each and every section thereof are equally binding on all sub-contractors and material men.

No work shall be sublet without the approval in writing of the Engineer and the Owner. No sub-contractor or person, firm or corporation furnishing or installing material will be recognized by the Engineer except as an employee of the Contractor.

CHANGES.

Materials and work not according to plans and specifications will be rejected and replaced at Contractor's expense, unless Contractor has a written order as to his authority for such change or substitution.

WATCHMAN.

The general contractor shall employ a man for watching the work at all times outside of regular working hours.

TIME.

Time is the essence of this contract and each contractor shall employ as many men as practicable in the erection and execution of the work of his contract, hastening the same forward to completion in such a manner as is consistent with good building in the opinion of the Engineer.

PREMISES.

All contractors shall carefully examine all of the premises in order that they may fully understand the nature of the work and its scope.

LABOR.

Only union labor is to be employed on the building.

SPECIFICATIONS
FOR
MASONRY

FOR MATERIALS AND WORK FOR A BUILDING
TO BE CONSTRUCTED AT
CHICAGO, ILLINOIS,
ACCORDING TO DRAWINGS AND SPECIFICATIONS.

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GENERAL.

This contract insludes all excavating, grading, sand and cinder filling, cut stone, brick work, tile work, water-proofing, fire-proofing of steel work, etc., necessary to complete this building, according to these specifications and accompanying plans.

PERMITS.

Take out and pay for all necessary permits.

EXCAVATION, GRADING AND FILLING.

Do all necessary excavating so as to be in all cases six (6) inches below the underside of floor slab. Excavate all trenches for footings, foundations, etc.

Excavate for pits where shown.

Do all necessary filling where required to come up to proper grade.

Grade and fill basement area for cinder filling, thoroughly flooding area with two inch stream of water and tamp earth solidly.

Bring basement to proper grade after the pipes are laid.

Remove all excess and surplus earth from premises, sidewalks and streets.

CINDER FILL.

Lay cinder fill over entire basement area. Fill to be six (6) inches thick, unless otherwise shown on plans.

All cinders to be clean steam-boiler cinders, well flooded and tamped.

BASEMENT FLOOR.

Over cinder fill lay five (5) inch concrete floor, with one (1) inch top finish as specified elsewhere in these specifications.

TOP FINISH.

The top finish for concrete floors, shall consist of a mixture of one part Portland cement and two parts of clean, coarse torpedo sand. This top finish shall be not less than one (1) inch thick.

PIT.

Lay concrete floor and cinder fill in elevator pit, similar to basement floor. Pit must be of depth shown on plans.

All pits must be waterproof. Pitch floor to drains.

COMMON BRICK.

Build all walls unless otherwise called for or shown, of sound, hard burned common brick, laid with shove joints in lime mortar tempered with cement, bonded into walls with continuous headers every sixth course.

All joints exposed in finished work will be flush.

Lay all brick above roof in cement mortar; this includes tank tower, chimney, etc.

Brick throughout the building shall be laid in lime tempered mortar, containing ten per cent (10%) cement unless otherwise called for on plans or specified.

All walls extending above roof to have vitrified tile coping set in cement mortar, unless otherwise shown or specified.

Build ledges for the support of floors and corbel out under girders, floors, and concrete work, where shown.

All proper holes and recesses must be left or cut in walls for steam pipes, drains, gas, electric and water pipes, as directed on the job by the superintendent, or as shown on plans.

Lay in cement mortar, all piers in driveway, and where shown on plans.

FACE BRICK.

Face entire front of building and returns, with face brick, to be laid in mortar selected by Owner.

Base estimate on face brick worth Eighteen Dollars ($18.00) per thousand.

The face brick shall be selected face brick, of shape and color acceptable to the Owner. The brick must be securely tied to construction. Joints to be raked joints, approved by the superintendent.

CHIMNEY.

Build chimney of common brick laid in cement mortar, of size as shown on plans. Provide chimney with concrete cap.

Line chimney with four (4) inch fire brick, with two (2) inch air space.

CUT STONE.

All cut stone shall be Bedford limestone, smoothly rubbed. All plain window sills shall be 5-1/2 inches thick, beveled sills extending two inches into brick work and under frame. Door steps shall be seven (7) inches thick and full width of wall. All projecting stone shall have deep drip.

Cut stone shall be firmly bedded and anchored in place.

The stone shall be cut in accordance with Engineer's details and this contractor shall submit 1/2 inch scale shop drawings and full size details of all ornamental stone work profiles to Engineer for approval.

All concealed portions of stone shall be coated with R.I.W.#110 or No. 3 Dehydratine before delivery.

CLEANING.

Clean down thoroughly all face brick and cut stone with acid and wire brushes and point all joints as required.

PENT HOUSE.

Build pent house over stair shaft.

DRIVEWAYS.

In shipping court, in rear of building, run driveway to alley, constructed as follows: Excavate to eighteen (18) inches below the final driveway level, slope as shown on plans, flood and tamp same, then lay a bed of nine (9) inches of clean boiler cinders; on top of that, lay a base of seven (7) inch concrete, mixed in proportion of 1-3-5, and on top of that, lay a two (2) inch cement finish top, made of 2-3 mixtures, and corrugated with 1/2 inch deep grooves.

WATERPROOFING.

All outside concrete walls in building below sidewalk grade must be waterproofed either with an integral waterproofing compound, or some waterproofing compound applied on the inside of the wall, all subject to the approval of the Engineer.

FIREPROOFING.

Where steel beams and iron columns are shown, fireproof with concrete; build this concrete in place, in proper forms and well tamped. Fireproof girder over driveway solid with concrete, projecting at least two (2) inches beyond the outside steel projection. Wrap lower flange of beams with wire lath.

PATCHING.

All patching of masonry, cut stone, concrete or other work of this contract, shall be done by this contractor, using proper materials in an approved manner. Clear off all mortar from projecting brick courses, pipes, beams, floors, etc.

GENERAL NOTE.

Bed all sills, plates, anchors, etc., in mortar, as required.

All work must be neat, plumb, and accurate as well as secure.

Remove all rubbish and surplus material, from building and premises and leave same clean and in first-class condition at completion of contract.

The above specifications with plans, is intended to cover a first-class job of masonry and will be so interpreted.

SPECIFICATIONS
FOR
PLAIN AND REINFORCED CONCRETE WORK

FOR MATERIALS AND WORK FOR A BUILDING
TO BE CONSTRUCTED AT
CHICAGO, ILLINOIS,
ACCORDING TO DRAWINGS AND SPECIFICATIONS.

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SCOPE OF WORK.

These specifications are for all plain and reinforced concrete work in this job, such as footings, foundation walls, piers and walls below grade, etc., all as shown on plans or called for in these specifications.

REINFORCING STEEL.

All reinforcing bars except as hereinafter noted, shall be either cold twisted square bars or hard grade deformed square bars rolled from new billets and must meet the requirements of the standard specifications, as adopted by the Association of American Steel Manufacturers in 1910 and revised in 1912.

FORMS AND CENTERING.

All forming lumber is to be dressed one side and two edges, and must be free from knot holes. Great care must be exercised to obtain tight joints and true lines.

The forms are to be erected as far as possible with wedges and must be built sufficiently strong to carry the weight of the concrete without deflection or bulging of any kind. The forming must be allowed to remain in place until the concrete is thoroughly set and able to carry its own weight and that of the floor above.

All forms must be thoroughly wetted before the placing of concrete.

CONCRETE.

All concrete required for this work shall consist of American Portland Cement, sand and gravel.

CEMENT.

The cement used in connection with this work shall be a well established brand of American Portland Cement, satisfactory to the Engineers, which has been extensively used in similar work and tested to conform with the requirements recommended by the American Society for Testing Materials.

SAND.

All sand shall be clean, coarse, torpedo sand, free from loam, clay and vegetable matter.

CRUSHED STONE OR GRAVEL.

All stone shall be broken lime stone, free from quarry refuse or stone dust, and of size to pass through a 3/4 inch ring. If gravel is used, it must be clean washed gravel, crushed so that it will pass through a 3/4 inch ring.

PROPORTIONS.

All concrete for footings and walls shall be proportioned one (1) part cement, three (3) parts sand and five (5) parts gravel.

MIXING CONCRETE.

Concrete shall be machine mixed in an approved batch mixer, acceptable to the Engineers, all ingredients being carefully measured in boxes or measuring bins. The quantity of water shall be so gauged as to give a uniform mixture of the consistency generally known as semi-liquid or "wet-mix".

Concrete leaving the mixer must be uniform in appearance and the mixing process must be carried on until this condition is obtained.

PLACING CONCRETE.

All forms must be absolutely clean and free from shavings or foreign matter before any concrete is placed. All concrete must be deposited in forms within ten minutes after leaving mixer.

All concrete shall be thoroughly spaded and sliced to the end that all air, water pockets and bubbles are removed from the mixture.

PLACING CONCRETE IN FREEZING WEATHER.

When the temperature of the air is below 45 degrees Fahrenheit, the water shall be heated to a temperature of 110 degrees. When the temperature is below 30 degrees Fahrenheit, artificial heat shall be used to assist in curing the concrete, and this must be continued until such time as in the opinion of the Engineer the concrete is thoroughly cured and dried throughout.

SETTING STEEL.

Steel must be free from rust scales or any foreign substance, although a thin film of rust is not objectionable.

Steel must be properly braced, supported and otherwise held in position so that the placing of the concrete will not change it.

DISCONTINUING WORK.

Where one day's work joins that of another, the joints shall be thoroughly picked and washed, also grouted with a coat of neat cement immediately previous to beginning new concrete work.

DEFECTIVE WORK.

If any of the work is found defective on the removal of forms, to a point, which in the opinion of the Engineers will materially weaken the structure, it is to be cut out and replaced with sound work in such a way as to bring the building up to its required strength without cost to the Owner.

Concrete Specifications-(continued)

FOUNDATIONS.

Build all foundations, piers and walls up to lines indicated on drawings. If foundations come over cisterns, cesspools or other excavations, fill same with concrete as required.

PATCHING AND FINISHING.

After removal of the forms, any places in the surface of the concrete not properly filled, are to be gone over with cement mortar and finished as near as possible like the portions not requiring patching.

SPECIFICATIONS

FOR

CARPENTRY

FOR MATERIALS AND WORK FOR A BUILDING

TO BE CONSTRUCTED AT

CHICAGO, ILLINOIS.

ACCORDING TO DRAWINGS AND SPECIFICATIONS.

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SCOPE OF WORK.

This contractor must furnish and place, all Carpentry work, mill work, anchors for carpentry and mill work, hardware and other work, as specified herein.

QUALITY OF MATERIALS.

All materials shall be of the best of their respective kinds, obtainable in the Chicago market.

LUMBER.

All timbers and laminated floor materials used in this building shall be of dense, Southern yellow pine and shall conform to the classification and specification for Southern yellow pine as adopted by the American Society for Testing Materials, August 21, 1915. The grade of pine used shall be No. 1 common, long leaf yellow pine.

All timber shall be strictly first class, entirely free from sap, shall have been cut from live trees, sawed true with square straight edges, shall be out of wind and full size and shall be close grained and free from wind shakes, unsound or

loose knots, numerous knots or knot holes, decayed wood, worm holes, cross grain, wane or other defects impairing its strength or durability.

Before purchasing this timber, the contractor must notify the Engineer where the timber is to come from and obtain his approval before purchasing same. Each piece of timber must have stamped on it name and location of mill.

All timbers shall be dry and thoroughly seasoned.

JOISTS.

All joists throughout shall be of sizes shown, free from all imperfections and when placed into position, shall be in perfect surface with each other, top and bottom.

Joists for headers and trimmers around openings, etc., shall be supported and framed to each other or to girders with iron stirrups. Joists shall be well anchored to walls, fitted with wrought iron anchor plates as specified under ANCHORS.

Frame for all stairs and different levels of floors.

LAMINATED FLOOR.

First and second floors to have 3" x 8" laminated flooring of long leaf yellow pine, securely spiked with forty (40) "D" spikes every twenty (20) inches. These laminations shall be surfaced on three inch sides and lower edges beveled. Every eighth plank to be spliced at the center of panel.

Where laminated floors come in contact with masonry walls, they shall be anchored into masonry with pin anchors,

2'6" long, spaced 4'0" centers. All wood bearing plates receiving laminated floors, shall be anchored to masonry. All laminations shall have full bearing on masonry and girders.

GIRDERS.

Girders shall be free from shakes and large knots and free from sap, perfectly straight, exposed bottom edges rounded.

Built up girders shall have oak or maple 7/8" x 4" separators, bolted with bolts about 5'0" centers, as shown. All anchors, bolts, straps, etc., will be furnished and set by this contractor.

Notch bottom of wall girders to receive cast iron bearing plates. Cut girders to frame around columns, as shown on plans. Girders at columns to have steel straps on both sides.

POSTS.

All posts shall be dressed on four (4) sides not over 1/2" scant. Posts to be straight and plumb. Bore 1-1/2 inch hole lengthwise through the middle of each post and 12 inches from bottom and top 1/2 inch hole. Corners to be beveled off.

All post caps and bases will be furnished by structural steel contractor and are to be set by this contractor.

PAPER.

Lay two (2) thicknesses of coated waterproof paper over all floors before receiving finished flooring.

FLOOR PLANKS.

All stories above second floor to have surfaced one side 2-5/8" x 5-1/4" #1 common long leaf yellow pine planks, tongued, grooved and beaded, known as factory flooring, blind nailed for under floor.

FINISHED FLOORS.

All floors above basement to have kiln dried #1 common factory maple, free from loose knots, sap spots and defects. This flooring shall be 2-1/4" face, 13/16" thick, tongued and grooved on sides and heading joints. Place a 3/4 inch quarter round at walls and around posts.

ROOFS.

All roofs to be covered with long leaf yellow pine boards, 2-5/8" x 5-1/2" and blind nailed. They shall be well seasoned, surfaced on both sides, tongued, grooved and beaded.

Pitch roof, as indicated.

FLOOR FOR ELEVATOR PENTHOUSE.

Build three (3) inch yellow pine plank floor for elevator machine floor in penthouse. Elevator contractor will furnish steel beams. This contractor to furnish timber beams, where necessary.

PLATFORM AROUND SPRINKLER TANK.

Build three (3) inch yellow pine plank platform, 1'6" wide around sprinkler tank on supports furnished by others.

Also build a frost proof boxing for main sprinkler rizer above roof.

WINDOWS.

All fireproof windows will be furnished by another contractor.

All remaining windows in all stories and above roof, except where otherwise marked on plans or specified, to be box frames with 1-1/8" yellow pine pulley stiles, 2-1/4 inch standard pulleys, 1-3/4 inch pine sashes, 2-1/2 inch wide with 2-1/4 inch rabbetted check rail and four (4) inch rabbetted bottom rail; all to have extending stiles. Sash must be hung with Samson solid braided "spot" sash cord. Sash to have galvanized iron sockets. For size and design see plans and detail drawings.

Furnish and install window cleaning device on all frames. Outer window casing of box frames to extend 1-1/2 inch into brick work to form a wind stop.

All windows and door frames, where same come in contact with lintels, steel beams or other iron work must be secured to the lintels with lag screws, furnished by Carpenter.

Space between window head and lintel must be caulked with oakum; cover space with neat dressed strips. All window sash to have two (2) extra heavy bar sash lifts and strong sash locks. The joint at inside of window frame and brick jamb must be covered with felted wood strips.

DOORS.

The main entrance doors and frames shall be oak.

Frames 2-1/2 inches thick; doors 2-1/4 inches thick, of three thicknesses, panelled as shown, with loose wood glazing mouldings secured by brass screws. Build transom, trim inside and outside as required. Provide on each side of door, sheet brass kick plates, door checks; ornamental extra heavy store door handles with cylinder lock and three loose pin butts; transom sash lift and three heavy butts for sash; all hardware bronze finished.

Toilet room doors to be of oak 1-3/4 inches thick.

BUMPERS.

Wooden bumpers inside shipping driveway at alley, must be oak, all to be strongly anchored and bolted to building walls, as shown on plans and as may be directed by the Superintendent.

Contractor must furnish all necessary bolts. Outer washers for bolts to be countersunk.

STAIRS.

Build stairs as per plans, in the most substantial manner from thoroughly seasoned material, treads and risers tongued and grooved together both front and back. All treads and risers nosed into wall strings, wedged and glued thoroughly.

Stairs which are four (4) feet in width or over, must have two (2) inch yellow pine risers, two (2) inch maple treads and three (3) inch yellow pine stringers.

Stairs less than four (4) feet wide to have two three (3) inch yellow pine stringers, 1-3/8 inch yellow pine risers and 1-3/8 inch maple treads.

WOOD BUCKS, BLOCKS, ETC.

This contractor shall furnish all necessary wood blocks, bucks, grounds, etc., required around openings.

SLIDES.

Build movable slides and guides for coal room of two inch by six inch lumber for entire height of coal room.

WATER CLOSET PARTITIONS.

All water closet partitions to be of matched flooring 7/8 inch thick, dressed, strengthened by 2" x 4" posts and 2" x 4" tops and bottom rail, all with panelled doors 1-1/8 inch thick to swing. To be fitted with heavy hinges, japanned and to have door pulls and bolts.

SCUTTLE.

Build a scuttle at elevator penthouse roof, with cover complete.

HARDWARE.

This contractor to furnish and set all shelf hardware except that which comes in connection with metal doors and windows. Provide checks on all swinging doors.

All doors to have cylinder locks and latches and are to be hung on heavy butts. Sash to have heavy locks and bar lifts. All transoms must be equipped with pivots and adjusters.

Provide clothes hooks on toilet stall doors.

MISCELLANEOUS.

When roof is completed on building, enclose all openings, put on temporary doors and locks for outside doors; do all necessary carpenter work in connection with pipe fitting, sprinkler system, plumbing, iron work, etc. Furnish and run all beaded boards, where directed; box in pipes, make good all damages to wood work, cover all exposed cut stone and tighten all bolts, etc.

PRIMING.

All frames shall be primed with oil all sides before being brought to the building.

ANCHORS, STRAPS, ETC.

This contractor is to furnish and install joist and girder straps as detailed, anchors for laminated flooring, anchors for wooden plate under laminations, etc. Laminated floor anchors 2 feet 6 inches long, four feet centers running into masonry with pin in walls.

GENERAL NOTES.

In all work, set all nails well, leave wood clean and well sand-papered.

All work must be neat plumb and accurate, as well as secure.

Ease all sash and doors needing attention, to the satisfaction of the Owner before completion of contract.

Remove all rubbish from premises and leave all clean and in first class condition at completion of contract.

The above specifications with plans is intended to cover a first-class job of carpentry and will be so interpreted.

SPECIFICATIONS

FOR

STRUCTURAL STEEL AND IRON

FOR MATERIALS AND WORK FOR A BUILDING
TO BE CONSTRUCTED AT
CHICAGO, ILLINOIS,
ACCORDING TO DRAWINGS AND SPECIFICATIONS.

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SCOPE OF WORK.

This contract shall furnish, fabricate and erect and install in place all structural steel and cast iron work required for the construction of the building as shown on the drawings and as hereinafter specified.

This work includes girder over driveway, steel lintels, cast iron columns in boiler room, steel post caps, cast iron post bases, steel beams for sprinkler tank supports, girder and joist wall plates, wheel guards and all other structural steel or iron work shown or called for on plans.

This contractor shall hoist and place all his material.

WORK NOT INCLUDED.

This contract does not include reinforcing bars.

The miscellaneous and ornamental iron will be furnished by another contractor, and the specifications for this work shall be consulted by this contractor.

HOLES FOR ANCHORS.

The contractor shall accurately locate and punch or drill all holes required for properly anchoring the brick and stone work.

WAGON WHEEL GUARDS.

Furnish two cast iron wheel guards at piers in shipping court, same to extend on both sides of pier and to be of 3/4" metal, not less than 20" high, and to have at least 6" horizontal projection at the base. Provide on top of same, seats to receive 4" x 4" x 3/8" corner angles.

POST CAPS, BASES, ETC.

This contractor is to provide all post caps built and of sizes shown on plans. Column bases to be of cast iron as shown. Wall bearing plates to be of steel for steel beams or girders, and cast iron for wooden girders or joists.

BEAMS.

All beams where shown must be of sufficient length to give proper bearing on brickwork (not to exceed 125# per square inch). Drill all necessary holes for other connections.

GIRDERS.

Second floor girders over driveway must have double cast iron separators, spaced not more than five feet apart. Girders resting on masonry piers must have steel bearing plates figured on basis of 125# per square inch bearing on masonry.

COLUMNS.

Provide cast iron columns in boiler room, as shown on drawings. The cast iron columns with the bottom and top plates turned off at ends exactly perpendicular to axis of column.

Provide brackets, plates, dowels, etc., all as shown to receive wood columns and girders. All cast iron must be tough gray iron, free from injurious cold short or blow holes.

LINTELS.

Lintels must be provided as shown on plans or called for in these specifications. Use cast iron separators where two or more structural shapes other than angles, are used.

If two angles are used, they must be either riveted or connected with wrought iron separators. Lintels to have not less than 8" bearing over walls. Provide holes in all windows and door lintels with 5/8" lag screws to secure wooden frames and window frame heads.

PAINTING.

All iron and steel, before leaving the shop, shall be thoroughly cleaned of all loose scale, dirt, rust and oil, and shall then receive one cost of paint, as hereinafter specified.

In the riveted work, surfaces coming in contact, bottoms of bed plates, bearing plates and all portions inaccessible after erection, shall receive two coats of paint.

After the structure is erected, all mud, dirt, plaster, etc., that may have accumulated during erection shall be removed and all abrasions in the first coat of paint shall be retouched; then the entire structure shall be painted with one additional coat of paint, as specified.

SHOP DRAWINGS.

Before work is commenced on this building, this contractor shall at his own expense prepare a complete set of working drawings and erection plans subject to the approval of the Engineers. Copies of two sets of these drawings shall be furnished to the Engineers without expense to them.

All structural steel must conform to the manufacturer's Standard Specification for medium steel as given in the Carnegie Steel Company's Pocket Companion of 1913. Details, where not specially shown on drawings, must be made to develop the full strength of the member connected under the load applied, in accordance with the City Ordinance.

SPECIFICATIONS

FOR

FIREPROOF DOORS AND MISCELLANEOUS IRON WORK

FOR MATERIALS AND WORK FOR A BUILDING

TO BE CONSTRUCTED AT

CHICAGO, ILLINOIS,

ACCORDING TO DRAWINGS AND SPECIFICATIONS.

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SCOPE OF WORK.

This contract includes all iron and steel work in the building not called for in the structural iron and steel specifications. This contractor must familiarize himself with the latter specifications and figure all the iron and steel work not mentioned therein.

ELEVATOR SHAFT, FRAMES AND SILLS.

The doors to all freight elevator shaft openings, with the exception of the doors in the basement, shall be counterbalanced freight elevator doors, shall carry the Underwriter's label of approval, and be equipped with self-closing device.

The door to the basement opening of freight elevator shaft shall be steel rolling door, equipped with fuse link automatic closing device and carry the Underwriter's label of approval.

The jamb guards to all freight elevator shaft openings shall be constructed of 6" x 6" x 3/8" angle jambs, 4' 0" high, located where shown on plans. The sill plate to all freight elevator shaft openings shall be made of 5/16" checkered steel plate reinforced with angle irons. The sill shall be extended three (3) inches over floor and three (3) inches beyond jambs for protection of flooring.

ROLLING STEEL DOORS.

All rolling steel doors shall be made of No. 20 gauge galvanized steel, interlocking slats and shall coil directly above the opening in No. 20 gauge galvanized steel hodd. These doors are to be equipped with an endless chain hoisting device to raise and lower them. Where required by the Underwriters', these doors shall bear the label of the Underwriters' Laboratories.

At each opening where rolling steel shutters are called for, this contractor shall furnish and set in place, 4" x 4" x 3/8" angles on all four (4) corners of the opening in brick walls. Angles to extend the full height of opening and to be provided with anchors so that they can be anchored into the brick.

At each of these openings, this contractor shall also furnish a 5/16" diamond plate sill extending through the opening, properly reinforced on the other side with an angle iron which shall be provided with anchors. These shall be built into the brick.

IRON DOORS AND FRAMES.

At each opening where iron doors are called for on the plans, furnish and set in place a single swinging No. 12 iron door properly reinforced with angle iron and hung to angle iron frame. Doors will swing as indicated on the plans.

Each frame shall be equipped with 5/16 inch diamond plate steel sill extending through the opening and reinforced on both sides with steel angles and each door shall be equipped with spring check and suitable lock or locking device.

FIRE ESCAPE.

Furnish and set in place where shown, one stairway fire escape and counterbalance which shall be acceptable to the City and on completion, have same inspected by City and furnish City acceptance to Owner.

FIRE ESCAPE DOORS.

At openings leading to fire escape, furnish and set in place, hollow metal doors to swing as indicated. These doors shall be hung on 4" x 4" x 3/8" steel angle frames which shall be built into brickwork.

Each frame is to have a 1/4 inch checkered plate sill extending through the opening. The upper half of each door to be panelled with ribbed wire glass. Hardware for each door to be furnished and set by this contractor and to be standard hardware for this class of door and acceptable to the City and the Underwriters.

PENT HOUSE DOORS.

Pent house doors to be located and swung as shown on plans. These doors shall be constructed the same as the stair doors and shall be equipped with suitable lock or locking device. Each door shall have frame and sill, the same as the stair doors.

TANK WALL RAILINGS AND LADDER.

Provide two inch gas pipe railings and posts around sprinkler tank. Bolt posts to steel beams supporting tank. Provide a steel ladder from main roof to sprinkler tank platform. Ladder shall be built of 3" x 3/8" uprights and 3/4" square rungs, placed not more than 14" centers.

UNDERWRITERS' ACCEPTANCE.

On completion and before final payment is made, this contractor shall have all rolling doors, stair doors, freight elevator doors and other fire doors throughout the building inspected by the Chicago Board of Fire Underwriters and to furnish to the Owner a certificate of acceptance. All of the above work must also be acceptable to the Protection Mutual Fire Insurance Company.

SPECIFICATIONS
FOR
FIREPROOF WINDOWS
FOR MATERIALS AND WORK FOR A BUILDING
TO BE CONSTRUCTED AT
CHICAGO, ILLINOIS,
ACCORDING TO DRAWINGS AND SPECIFICATIONS.

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SCOPE OF WORK.

This contractor shall furnish and place all fireproof windows shown on drawings or specified herein, including all necessary anchors.

FIREPROOF WINDOWS.

All windows marked on plans "Fireproof Windows" or "F.W.", which includes windows in North and West elevations and above roof, to be standard closing and locking type, all sash standard pivoted on trunnions and must be arranged so that it can be revolved for cleaning. Every sash is to be equipped with fusible link and the sash when open held in position by a chain at the upper end, with proper extension to allow operation from floor.

All window sash and frame to be made of #24 galvanized iron, given a priming coat of red lead and oil, inside and outside, before delivery to building and glaze

on completion of building with 1/4 inch ribbed wire glass.

Frames to be securely anchored to walls.

All hardware to be Standard Underwriters' Hardware.

All sills must be filled solid with a rich Portland cement concrete. All metal windows must be straight, true and out of wind so as to close tight to frames and contractor must make same weather-tight and guarantee same for one (1) year.

SETTING FRAMES.

This contractor is to do all setting, fitting and caulking and frames must be promptly set as the walls go up, without causing any delay to other contractors.

SPECIAL CONDITIONS.

All of the foregoing material and work is to be completed with all appurtenances and fixtures required and to be acceptable in every respect to City Building Department and National Board of Fire Underwriters of Chicago, to obtain the lowest possible rate of insuramce.

OFFICIAL APPROVAL.

The contractor must procure Chicago Board of Fire Underwriters' acceptance and have the approval tags of the National Board of Underwriters' Laboratory attached to each window and will not be paid for this work until final inspection is made and final certificate of inspection issued and filed with the Owner.

SPECIFICATIONS

FOR

COMPOSITION ROOFING

FOR

MATERIALS AND WORK FOR A BUILDING

TO BE CONSTRUCTED AT

CHICAGO, ILLINOIS,

ACCORDING TO DRAWINGS AND SPECIFICATIONS.

-:- -:- -:-

SCOPE OF WORK.

This contractor must furnish all composition roofing for main roof and roof over pent houses. Also furnish all necessary flashing connections to down-spouts, etc., not included in the sheet metal specifications. All the work must be done according to Master Roofers Standard Specifications.

FELTING.

Over entire roofs, use one thickness of rosin sized sheathing paper.

First lay five thicknesses of #2 wool roofing felt, weighing not less than fourteen pounds (single thickness) to the square of one hundred feet. This felt to be smoothly and evenly laid and well cemented together, mopping not less than twenty inches, between each layer, with best roofing cement, using not less than 120 pounds of roofing cement to the square of one hundred feet. All joinings along the walls and around the openings to be carefully made. Then cover the entire

surface with a coating of roofing cement and screened gravel, to the square of one hundred feet, using not less than one-sixth of a cubic yard of gravel. The gravel to be what will pass through not larger than a 5/8" mesh screen and to be free from sand and loam.

Edges to down spouts, conductor heads and gutters well turned down, and secured to the roof in the best manner.

Flashing for skylights to cover the entire wooden curb.

Coat fire walls to coping with tar.

RECOATING.

After all other contractors have completed work on roof, all gravel and dust to be swept from the roof of this building, after which cover the entire surface with a coating of roofing cement, and screened and washed gravel.

GUARANTEE.

This roof to be guaranteed in writing for a term of five years. This guarantee to be filed with the Engineer before final payment is made.

SPECIFICATIONS

FOR

AUTOMATIC SPRINKLER SYSTEM

FOR A BUILDING TO BE CONSTRUCTED AT

CHICAGO, ILLINOIS.

-----:-----:-----

The General Conditions form part of these Specifications.

PERMITS.

This contractor will procure and pay for all permits, inspection certificates, etc., necessary, all according to City Ordinances, the Associated Factory Mutual Insurance Company's rules, and the rules of the Chicago Board of Fire Underwriters.

SCOPE.

This contractor must install complete a one source automatic sprinkler equipment. Entire work to be laid out so as to be acceptable to the Associated Factory Mutual Insurance Company and the Chicago Board of Fire Underwriters. It must include a complete job of sprinkler work, done in a neat and workmanlike manner.

SPRINKLERS.

The number of sprinklers required for this building should be obtained by this contractor from the above mentioned insurance companies.

Automatic Sprinkler System Specifications-(continued)

Separate controlling valves and drains to be provided for loading course and for other small portions of the building subject to freezing temperature.

The contractor to state in his bid, the number of sprinklers he intends to put in.

DEVICES.

All devices and materials used in equipment to be acceptable to the Associated Factory Mutual Fire Insurance Companies of New England and Fire Underwriters.

PIPE SIZES.

To be in accordance with Underwriter and Mutual 1895 Schedule and all pipes must drain to risers.

HANGERS.

To be of acceptable pattern and adapted to construction.

FITTINGS.

All fittings used in main water connections to be of long turn pattern and flanged where necessary.

GAUGES.

Install the necessary gauges at base of sprinkler system risers and for tank and pump, also mercury gauge for gravity tank.

VALVES.

Gate valves to be of the O. S. & Y. pattern, check valves to be of the straightway swing pattern and where underground, to be in pits easy of access.

FILLING PUMP.

Furnish and install fifty (50) gallon Electric Filling Pump, including foundation and suction from City main. Wiring outlet to be left within ten (10) feet of pump by others.

BASINS.

This contractor to build necessary valve basins for his work and furnish covers for same.

HEATER.

Provide heater for tank to meet the conditions.

WATER SUPPLIES.

TANK.

Erect, twenty five (25) feet above roof, a thirty thousand (30,000) gallon gravity tank, to be built, fitted, connected and erected in accordance with Underwriters' requirements. From tank run eight (8) inch pipe direct to underground, installing the necessary valves. Provide heating, filling, drain and overflow connections for tank and protect any exposed portion of tank riser against freezing.

STEAMER CONNECTIONS.

Provide double siamese steamer connections to sprinkler system.

ALARMS.

Provide standard system of alarms from system, with gongs at base of risers and upon alternating floors, connected to annunciator.

CONNECTION TO CITY MAIN.

Make three (3) inch connection to City main, installing the necessary valves.

UNDERGROUND WORK.

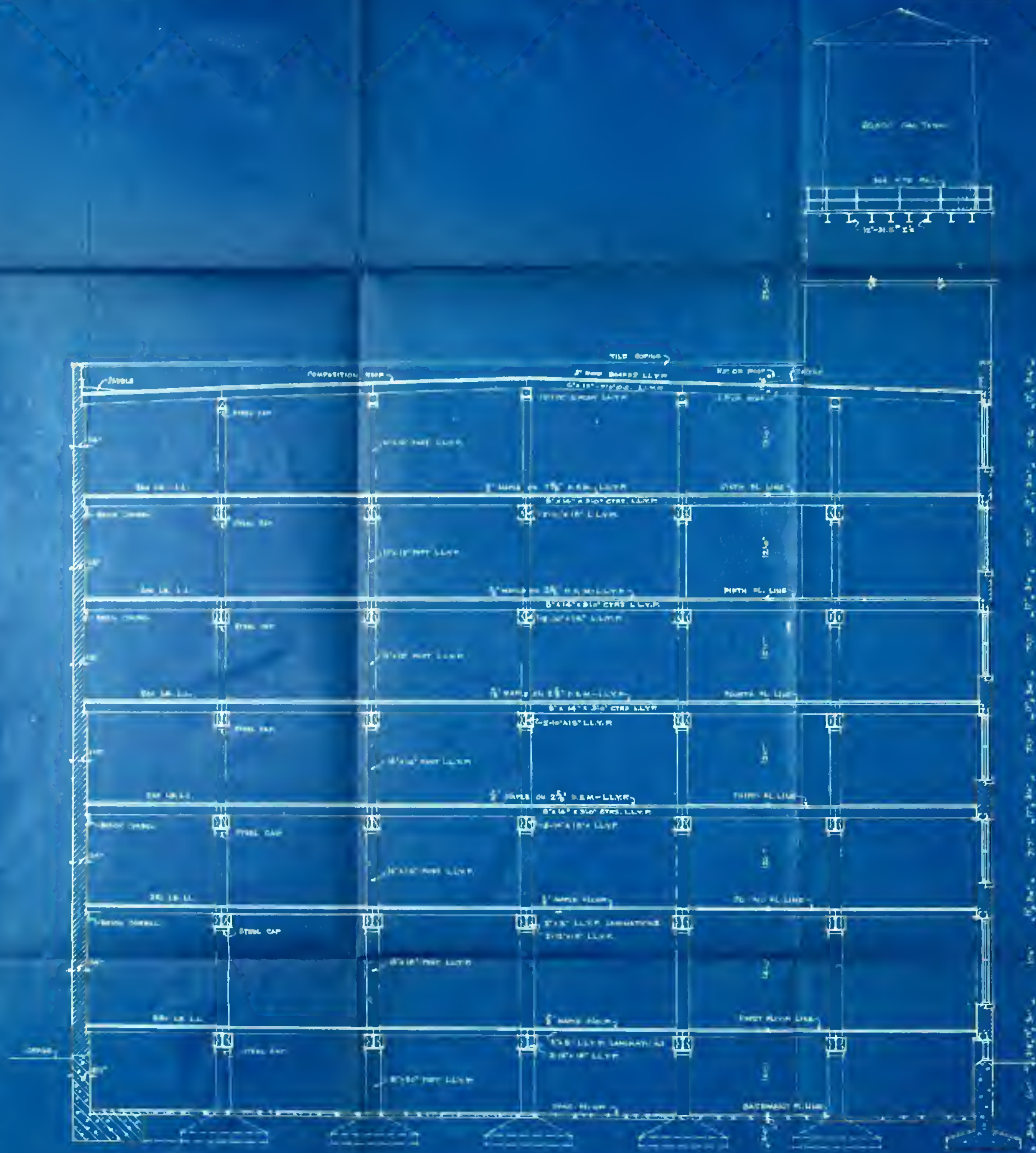
All pipes and fittings underground to be cast iron of standard weight and thickness, thoroughly leaded and caulked and placed deep enough in ground to prevent freezing and breakage, to be tested when laid and proven tight to hydrostatic pressure of two hundred (200) pounds per square inch for one (1) hour.

Provide connection to sewer. Excavate all trenches for underground work.

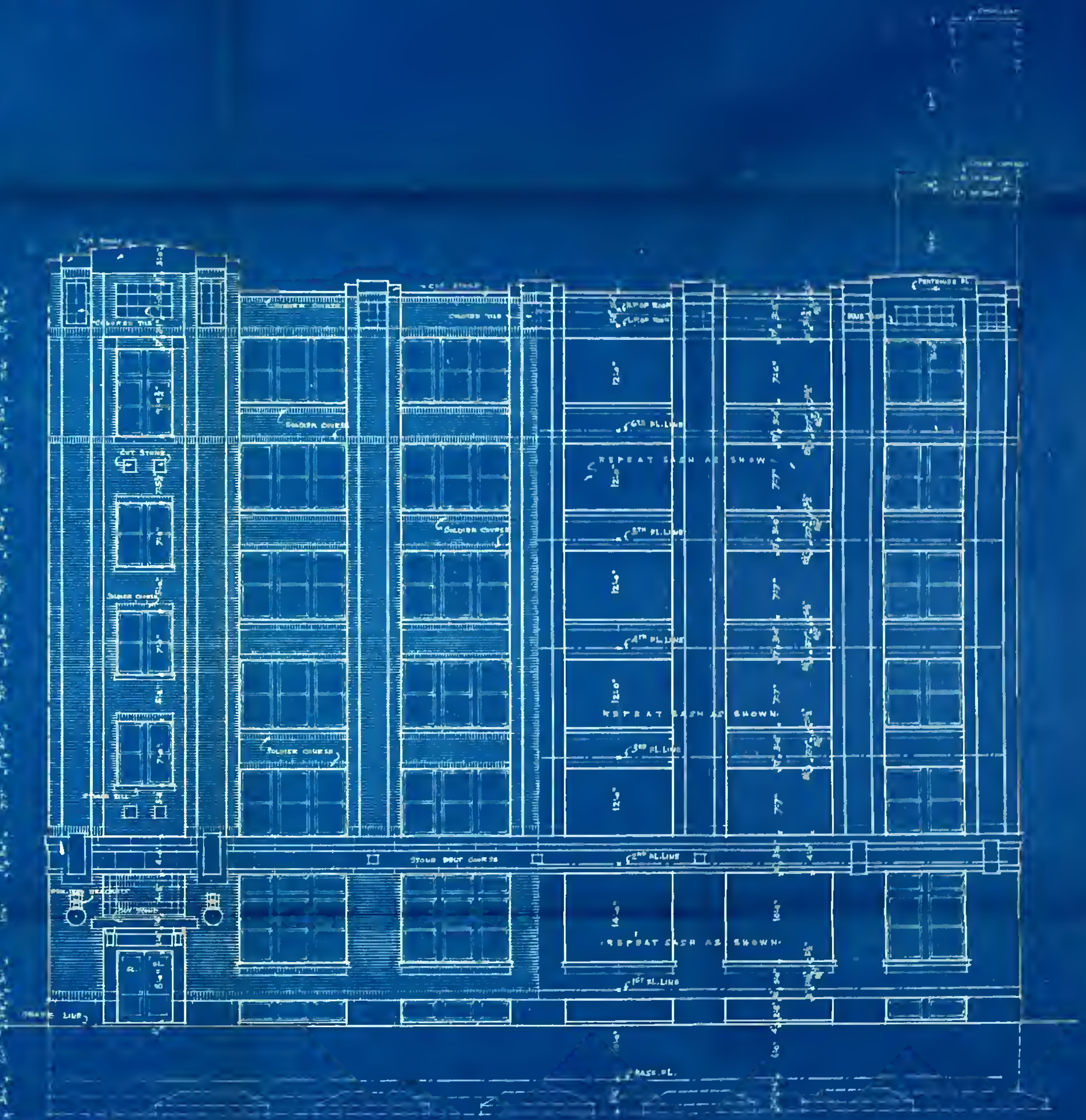
APPROVAL.

Entire equipment, when complete, to be subject to the inspection and approval of the Protection Mutual Fire Insurance Company of Chicago, and the Chicago Board of Fire Underwriters.

200



·CROSS · SECTION·
SCALE ¼ INCH EQUALS 1 FOOT



·FRONT · ELEVATION·
SCALE ¼ INCH EQUALS 1 FOOT

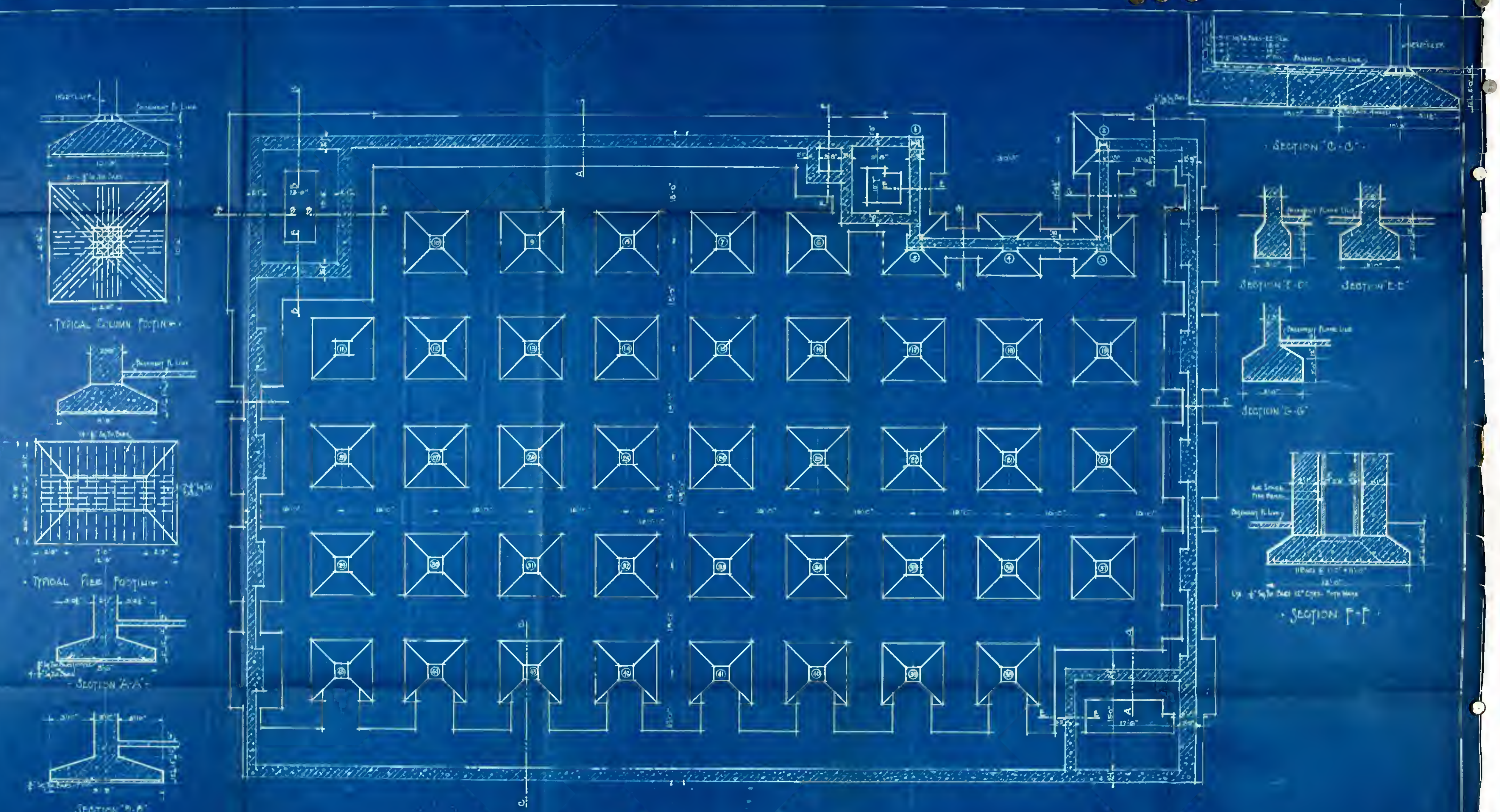
THESIS
OF
·PETER M. LEICHENKO & MAX L. LOEWENBERG·
FOR THE DEGREE OF
·CIVIL ENGINEER·

ELEVATION & CROSS SECTION·
MILL CONSTRUCTED WAREHOUSE
6 STORIES & BASEMENT.
TO BE LOCATED AT CHICAGO, ILL.
SCALE :- ¼ INCH EQUALS ONE FOOT·

SHEET NO
·1·
MAY 1917

201

2



THESIS

OF

· PETER M. LEICHENKO & MAX L. LOEWENBERG ·

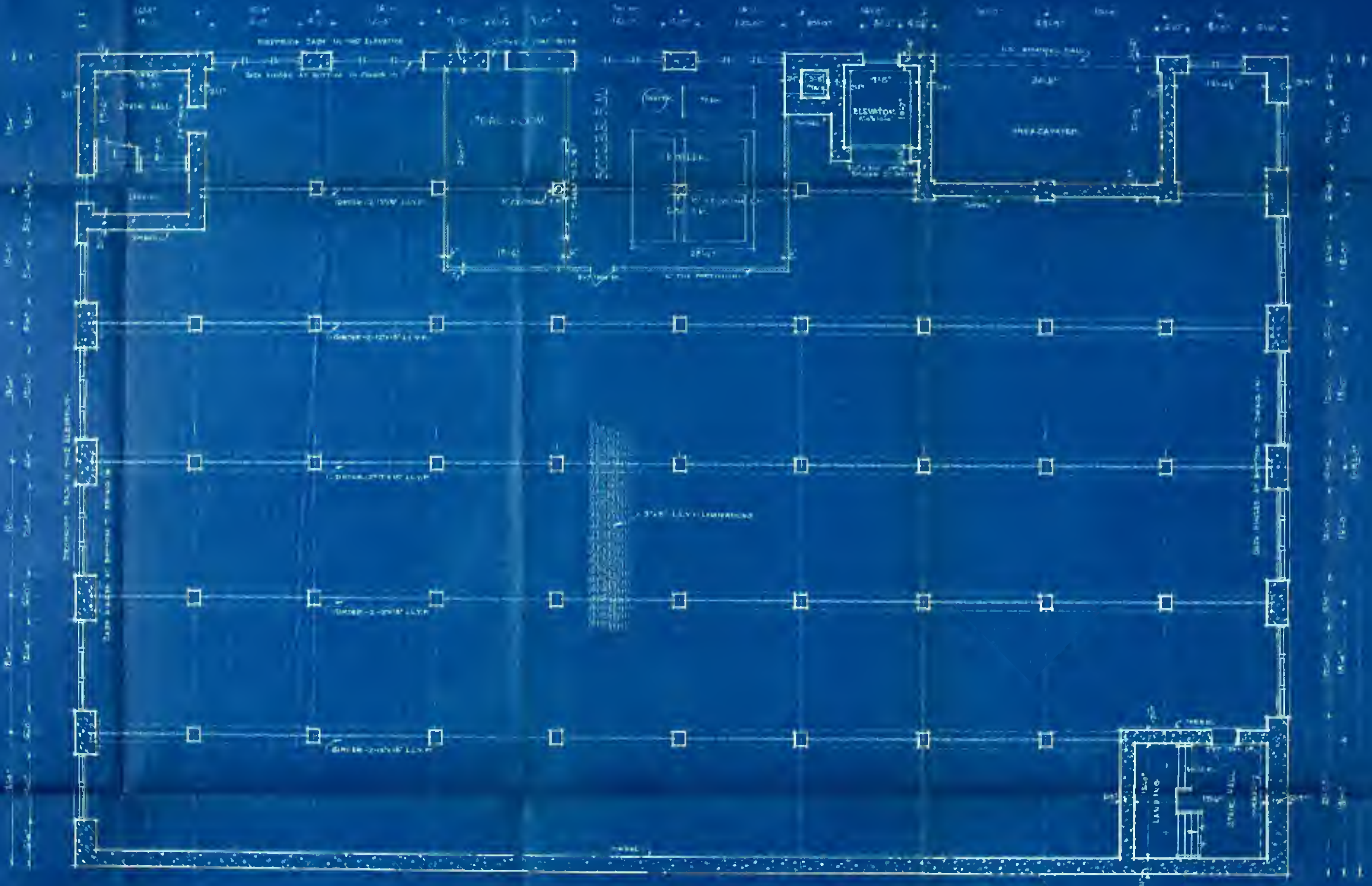
FOR THE DEGREE OF

· CIVIL ENGINEER ·

FOUNDATION PLAN ·
MILL CONSTRUCTED WAREHOUSE
6 STORIES & BASEMENT
TO BE LOCATED AT CHICAGO, ILL.
SCALE 1/8 INCH EQUALS ONE FOOT ·

SHEET NO
· 2 ·
MAY 1917 ·

202



THESIS

OF

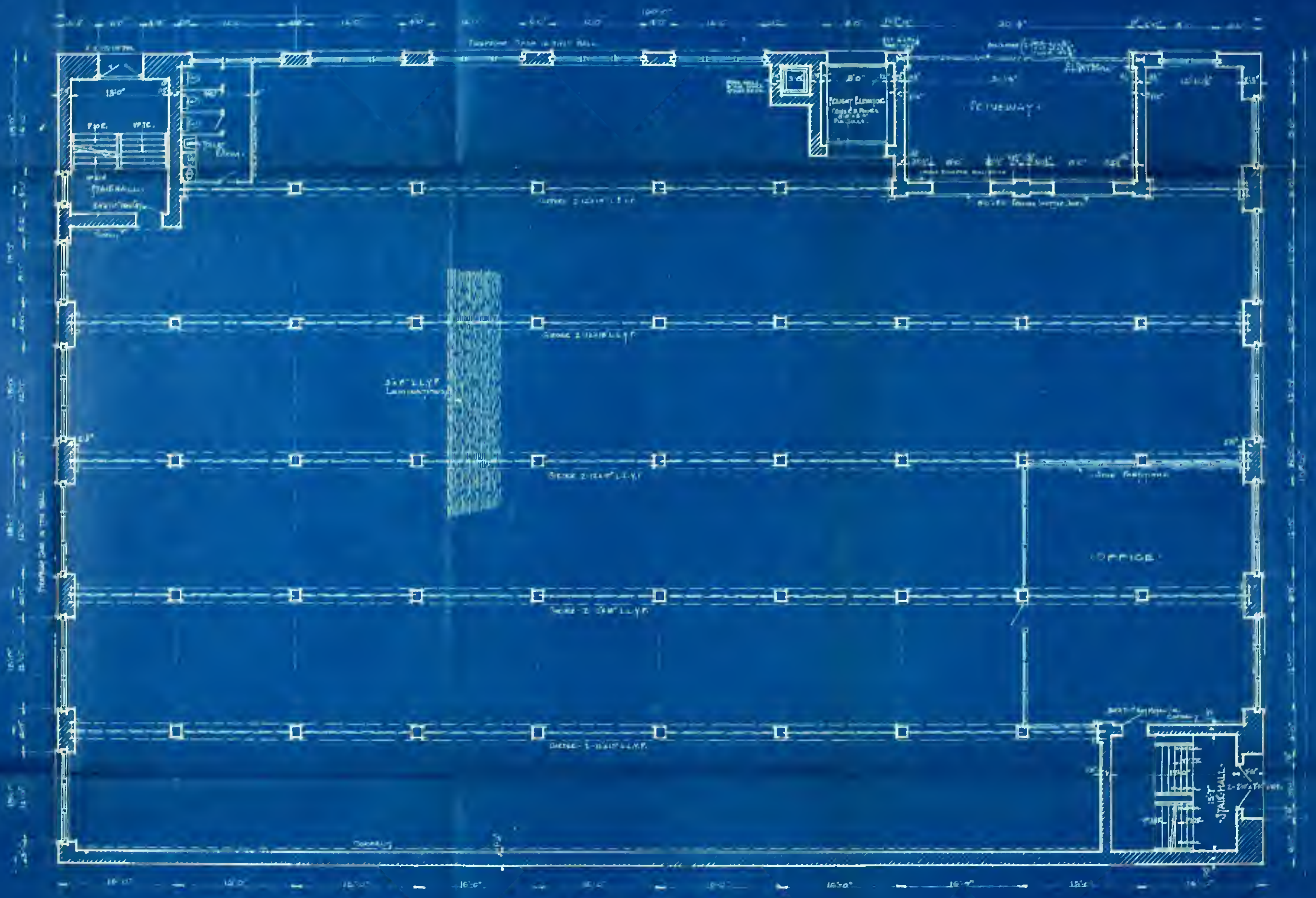
· PETER M LEICHENKO & MAX L. LOEWENBERG ·

FOR THE DEGREE OF

· CIVIL ENGINEER ·

BASEMENT FLOOR PLAN	SHEET NO
MILL CONSTRUCTED WAREHOUSE 6 STORIES & BASEMENT TO BE LOCATED AT CHICAGO, ILL.	·3·
SCALE: $\frac{1}{8}$ INCH EQUALS ONE FOOT.	MAY 1917

203



THESIS

OF

· PETER M. LEICHENKO & MAX L. LOEWENBERG ·

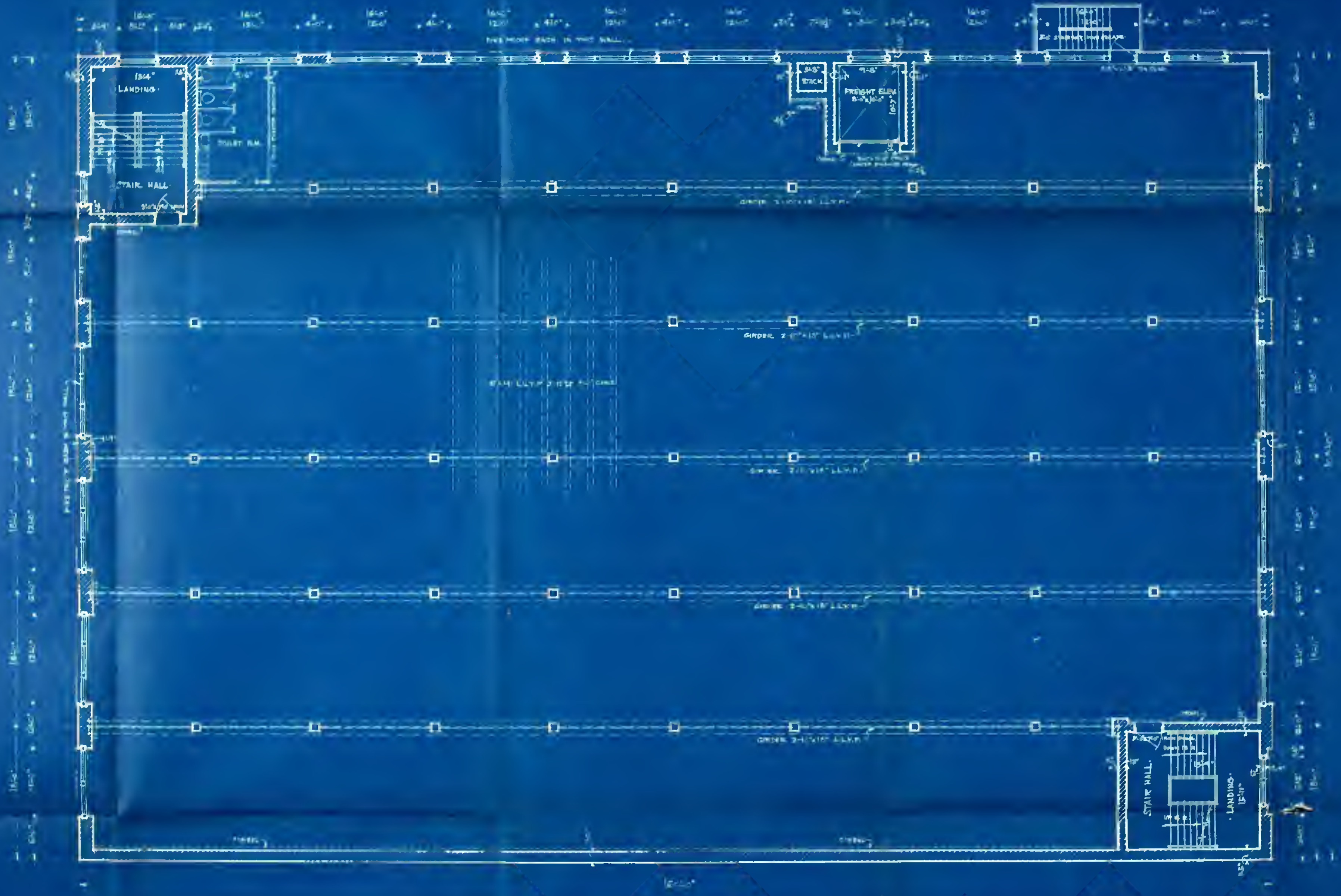
FOR THE DEGREE OF

· CIVIL ENGINEER ·

FIRST FLOOR PLAN ·
MILL CONSTRUCTED WAREHOUSE
9 STORIES & BASEMENT
TO BE LOCATED AT CHICAGO, ILL.
SCALE : 1/8 INCH EQUALS ONE FOOT ·

SHEET No: · 4 ·
MAY 1917

204



THESIS

OF

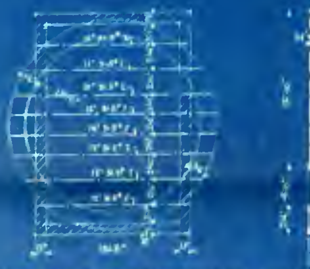
· PETER M. LEICHENKO & MAX L. LOEWENBERG ·

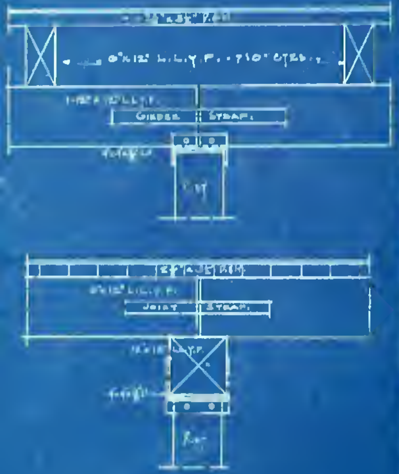
FOR THE DEGREE OF

· CIVIL ENGINEER ·

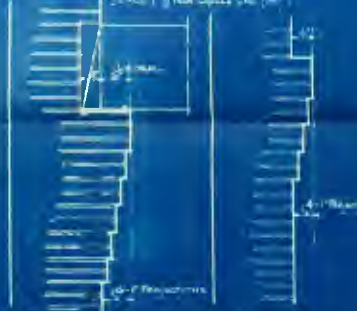
TYPICAL FLOOR PLAN	SHEET NO
MILL CONSTRUCTED WAREHOUSE 6 STORIES & BASEMENT · TO BE LOCATED AT CHICAGO, ILL.	·5·
SCALE :- 1/8 INCH EQUALS ONE FOOT.	MAY 1917.

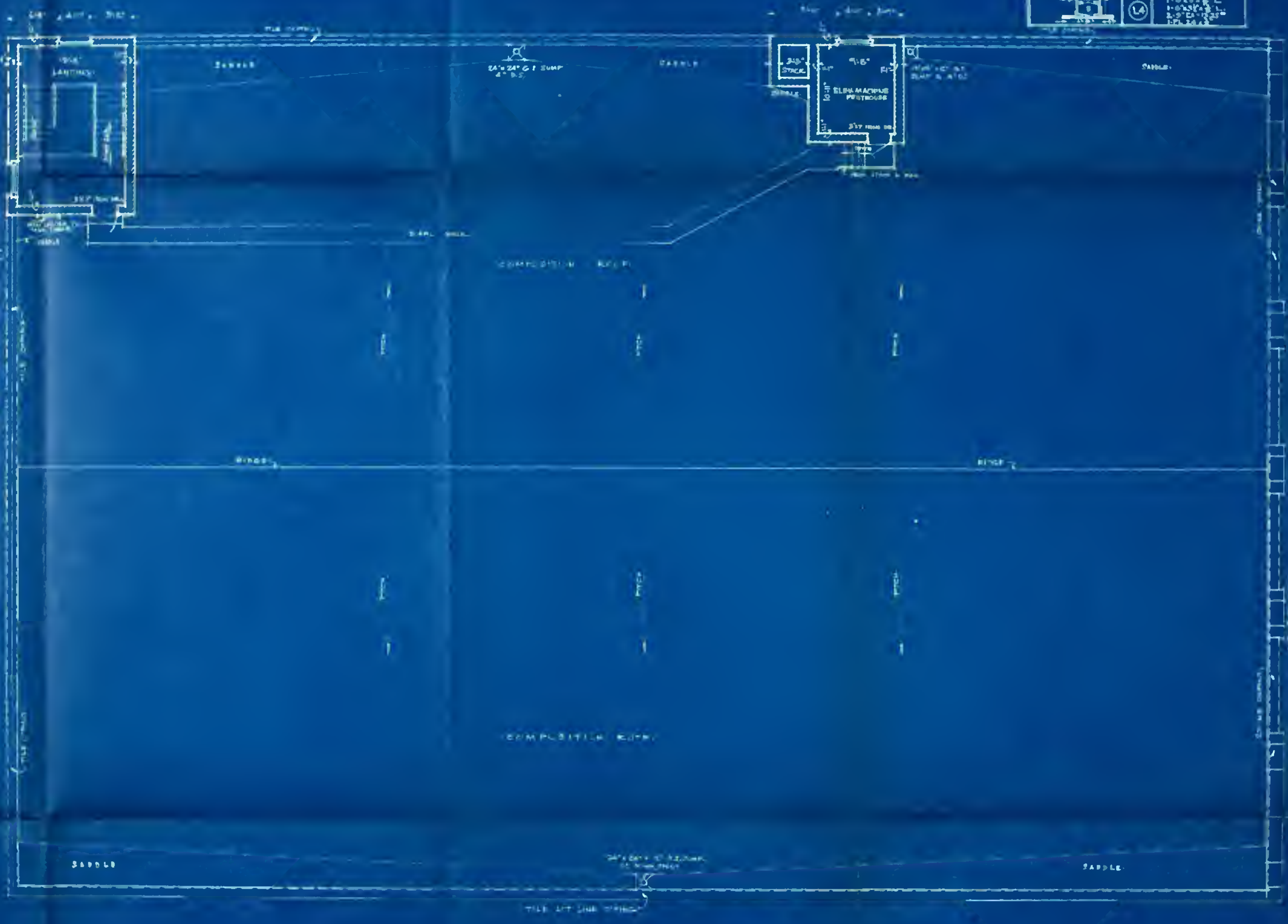
205


FRAMING FOR SPRINKLER TANK
Scale ½ inch equals 1 foot.



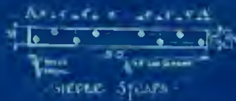
TYPICAL ROOF CONSTRUCTION
Scale ½ inch equals one foot.

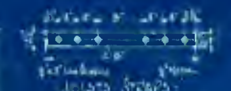

GIRDERS · JOISTS & LAMINATIONS ·
CORBEL DETAILS ·
Scale - ½ inch equals one foot.

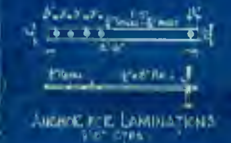


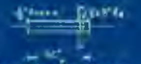
LINTEL SCHEDULE.

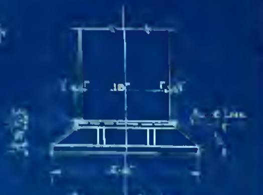
SECTION	MARK	MATERIAL
	L1	1-7" I-15# 1-PL. 12"x⅜"
	L2	2-6" [s-8# 1-PL. 16"x¼"
	L3	1-8" I-18# 1-8" [-11.25# 1-PL. 18"x⅜"
	L4	[illegible] [illegible] 2-9" [s-13.25# 1-PL. 24"x⅜"

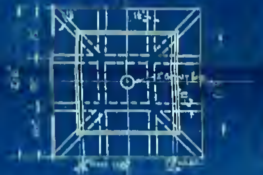

GIRDER STRAPS.

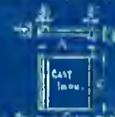

JOISTS STRAPS.


ANCHOR FOR LAMINATIONS


ANCHOR FOR WOOD WALL PLATES INTO WALL.

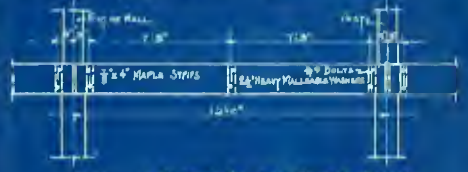

Post-Cap Iron


TYPICAL POST BASE DETAIL.
Scale ½ inch equals one foot.

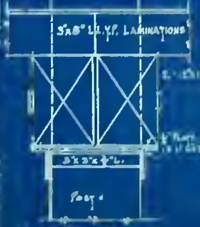


Wall Bearing Plate for Timber Beams.

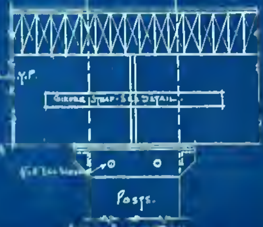
SCHEDULE OF WALL BEARING PLATES.		
BEAM	A	B
6"x12"	6½"	8"
8"x14"	8½"	10"
2-10"x18"	10"	24"
2-12"x18"	10"	28"
12"x12"	10"	8"



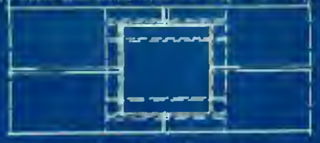
DETAIL OF GIRDER BOLTING - TIMBER BEAMS.
Scale ½ inch equals one foot.



END ELEVATION.



SIDE ELEVATION.


TYPICAL POST CAP DETAILS.
Scale ½ inch equals one foot.

THESIS
OF
· PETER M. LEICHENKO & MAX L. LOEWENBERG ·
FOR THE DEGREE OF
· CIVIL ENGINEER ·

ROOF PLAN & DETAILS
MILL CONSTRUCTED WAREHOUSE
6 STORIES & BASEMENT
TO BE LOCATED AT CHICAGO, ILL.
SCALE :- ⅛ INCH EQUALS ONE FOOT.

SHEET NO
·6·
MAY-1917.